VEGETATION CHANGE ALONG SALINITY GRADIENTS IN THE TIDAL MARSHES OF THE UPPER SAVANNAH RIVER ESTUARY

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

2002

ACKNOWLEDGMENTS

Many friends and colleagues have been involved in the opportunity for me to undertake and complete this dissertation. I would like to thank the members of my faculty committee, Dr. Mark Brown, Dr. Thomas Crisman, and Dr. Scot Smith, for their time and guidance. Especially, I would like to thank my major advisor, Dr. Clay Montague, for the many hours he spent in the field, in discussion, and in deciphering the first draft.

Many colleagues at Applied Technology & Management, Inc., in Gainesville provided invaluable assistance and some have spent literally thousands of hours in the field, managing data, and conducting analyses. This group includes George Otto and Kevin Flavin who kept a very stubborn datalogging network running under extremely harsh conditions. Also, Pete Wallace graciously shared his many years of experience in plant ecology. Thanks also go to Chris Ahern, Gary Bazemore, Jenny Carter, Robert Garrren, Matt Goodrich, Kostas Kalimtgis, Pete Peterson, Michelle Rau, Dan Rich, Bobby Richardson, and Fran Way for their participation in ways too numerous and diverse to list. Finally, special thanks go to Thomas Schanze for his patience and encouragement through what turned out to be a very long process.

The Georgia Ports Authority generously supported this work. Thanks go to Larry Keegan at Lockwood-Greene, Inc. and Bo Ellis at Applied Technology & Management, Inc., for facilitating the funding. Thanks go also to Sam Drake and

John Robinette of the U.S. Fish and Wildlife Service, Savannah Coastal Refuges for allowing access to the Savannah National Wildlife Refuge. Dr. Wiley Kitchens of the University of Florida Cooperative Fish and Wildlife Research Unit also provided many valuable hours of collaborative discussion.

Finally, I would like to thank my wife, Jean, for the years of support, encouragement, and love she has given. She, more than anyone else, allowed me to be more than I thought I could be. For that I owe her a debt of gratitude that can never be fully repaid.

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December 2002

Chair: Clay Montague
Major Department: Environmental Engineering Sciences

The tidal freshwater-oligohaline marsh interface was investigated in the upper Savannah River estuary. Tidal marsh vegetation, tide stages, and salinity were monitored from October 1997 through November 2001. Permanent belt transects for vegetation monitoring were established at ten locations chosen to bracket the salinity gradient between tidal freshwater and subsaline conditions. Marsh vegetation was monitored six times between November 1997 and October 2001, and data were collected on frequency and percent cover of each species. Automatic datalogging stations were used to continuously monitor tide stage and salinity at 12 locations. Tide stages were monitored both within tidal creeks and within the interiors of adjacent marshes. Salinity was monitored in tidal creeks, in high-tide surface waters within adjacent marshes, and in marsh sediments. High tides were shown to flood the marshes between 33.8 and 100% of the time, depending on location. Mean salinity in marsh sediments ranged from a low of

$0.4 \pm 0.3‰$ at the site farthest upriver to a high of $8.1 \pm 4.0‰$ at the site farthest downriver. However, between October 1997 and October 2001, salinity within marsh sediments rose at all sites, a trend that was attributed to a 3-year drought in the Savannah River basin. Ordination of vegetation data defined the vegetation assemblages of each belt transect and separated them along two major gradients. The primary gradient was salinity; however, the secondary gradient remained undefined, possibly indicating an influence of sediment consolidation and differences in elevation. Comparison of belt transects over the six separate sample periods indicated a subtle shift to more saline vegetation assemblages at some sites, a result that was again attributed to the drought conditions. Salinity distribution across the tidal marshes was determined to have a strong spatial component associated with proximity to an extensive network of tidal creeks, the remnants of agricultural water management systems constructed for the tidewater rice industry in the eighteenth and nineteenth centuries. The influence of the tidal creek system on the salinity distribution was determined to have potential use in river management actions that could preserve or increase tidal freshwater marsh habitat.

CHAPTER 1
INTRODUCTION

The upper Savannah River estuary contains a complex mosaic of tidal wetlands interspersed among braided river channels. This wetland mosaic includes tidal freshwater marshes intermingled with low-salinity oligohaline marshes. These marshes are bracketed upriver by tidal freshwater forests and downriver by extensive coastal salt marshes. Much of this system, in turn, is confined laterally by upland bluffs in close proximity to the main channels of the Savannah River. However, the tidal freshwater marshes occupy a unique landscape position. They are the product of significant tidal range acting over a flat elevational gradient and against a large volume of freshwater flow. This combination of environmental factors restricts tidal freshwater marshes to above the upriver extent of the estuarine salinity gradient (Odum et al. 1984). These environmental factors also endow tidal freshwater marshes with the potential for high production and diversity because the marsh receives the benefits of tidal import and export (i.e., the "tidal subsidy") without the physiologic limitations imposed by salt stress (Mitsch and Gosselink 1993).

The landscape components that drive marsh production have also fostered human productivity along the lower Savannah River. The City of Savannah was established in 1733 along the upland bluffs lining the river. The river was a source of freshwater and also provided a protected harbor, which has

since developed into one of the largest ports in the United States. The tidal subsidy that today supports freshwater marshes previously supported a vast agriculturally managed landscape of rice fields, which were the source of immense fortunes for their owners in pre-Civil War America.

Currently, the landscape of the upper Savannah River estuary reflects a diversity of conflicting land uses and management goals. Taking advantage of the tidal subsidy, many of the former rice fields are now actively managed for use by migrating waterfowl. Other fields were simply abandoned and have since developed into tidal freshwater marsh or reverted to tidal swamp. Some of the former rice fields have been permanently filled and developed for industrial or port-related uses. Construction and dredging associated with port expansion and maintenance continue to alter the tidal and salinity regime of the river, potentially affecting the interface between the freshwater and saline portions of the tidal marshes.

Against the backdrop of direct human activity are landscape-level changes attributed to sea-level rise. Rising sea level and the concomitant upriver migration of the salinity gradient drive the freshwater-saline marsh interface landward, promoting a state change in the landscape components (Ricker 1999).

Hackney et al. (1996, pg. 94) stated "vegetation is an indicator of specific hydrologic and chemical characteristics of established tidal marshes, even if the mechanism through which this occurs is not clear." Salinity has been shown in numerous studies to play the key role in the differences between tidal freshwater and salt marshes (Odum 1988). However, even in water bodies with gradual salinity gradients, the shift from freshwater to saltwater vegetation along the

gradient "is not a gradual process but occurs in a rather narrow zone of critical salinity" (Khlebovich 1990, pg. 5). This zone of "critical salinity" is where tidal freshwater marshes intergrade with tidal oligohaline marshes.

The oligohaline portion of the marsh may be an especially sensitive indicator of long-term change because of its intermediate position along the salinity gradient. Activities that can change water levels and salinities within estuaries include upriver dam construction and reservoir management, waterfowl management, bridge and causeway construction, navigation improvements such as jetty construction and channel dredging, and, in the case of the lower Savannah River, rice field construction and management. It is believed by some authors that these activities can cause rapid changes (Pearlstine et al. 1990), yet preliminary observations indicated very few changes after removal of a controversial tide gate that was constructed in the 1970s. Accordingly, this study focused on the response of this community to the salinity and water level regime impinging upon it. The response of the oligohaline community was measured in relation to that of the freshwater community upgradient and the more brackish system downriver.

Water levels and salinity in the Savannah River and its associated channels are subject to dramatic daily fluctuations because of constantly changing river flows and tide stages. While water levels and salinity are recognized as major environmental factors in determining vegetation distributions, constant fluctuation can also be expected in other environmental factors that may be less easily identified. These undefined factors may play fundamental, yet unrecognized, roles in driving the self-organization of the

ecosystem. Taken together, these myriad, simultaneous fluctuations can mask trends that occur over scales from a few years to a decade or more. The vegetation of the tidal marshes, however, may integrate these diverse fluctuations and reveal underlying trends. The interface between the tidal freshwater and oligohaline marshes may potentially provide an especially sensitive indicator of environmental changes within the river.

Use of the tidal freshwater-oligohaline marsh interface as an indicator of environmental change is contingent on defining its location and monitoring the primary influencing factors (i.e., salinity and water levels). Evaluation of the relationship of the two marsh types in relation to these primary environmental factors may help to identify additional yet-undefined environmental factors that also influence the vegetation distributions.

Study Area Description

Location

This study was conducted within the freshwater and low-salinity tidal marshes of the lower Savannah River (Figure 1-1). Throughout most of its length, the Savannah River occupies one channel and forms the border between Georgia and South Carolina. However, approximately 27 miles[1] upstream of its mouth, the river becomes an estuarine delta (Day et al. 1989) and divides into three braided channels named the Front River, Middle River, and the Little Back River (Figure 1-2). These channels in turn define the large islands – Argyle

[1] *The units used in this study are English units and not metric as may generally be expected in an academic treatise. However, this use of English units reflects the multidisciplinary nature of the much larger engineering project from which this dissertation is derived. In the overall project, which concerns deepening more than 40 miles of shipping channel and rerouting flows along perhaps another 10 miles, English units are the standard.*

Island, Ursla Island (also called Isla Island), Onslow Island, and Hutchinson Island – where most of the study area's swamps and marshes are located. However, additional expanses of swamps and marshes occur on the mainland margins of both the Georgia and South Carolina sides of the three channels. The Middle River eventually rejoins the Front River, leaving just two main channels: the Front River and the Back River. The Back River and Little Back River form the border between Georgia and South Carolina.

In general, the extent of the study area is defined upstream by the Interstate 95 bridge across the Savannah River and downstream by the Savannah River tide gate, a water control structure built across the Back River in the 1970s by the United States Army Corps of Engineers (USACE) and removed in 1991-92. The study area is bisected from east to west by the former US-17 (now GA-25 and SC-170), which was constructed in the 1930s. The City of Savannah is located along the Front River, downstream of the study area.

Estuarine Extent

Day et al. (1989) defined the functional boundaries of a riverine deltaic estuary as extending from near-shore coastal waters on one end to the upriver limit of tidal influence on the other. Between these two extremes is the main part of the estuary, characterized as a mass-mixing zone with strong physical, chemical, and biological gradients. Figure 1-3 provides a regional overview of the Savannah River estuary. Figure 1-4 provides a schematic of river miles along the lower Savannah River. A tidal range of 1 to 3 feet persists at the United States Geological Survey (USGS) gaging station above Hardeeville, South Carolina (Figure 1-5), approximately 38 miles upriver (USGS 2001), but no

tidal signal is observed at the gaging station near Clyo, Georgia, approximately 61 miles upriver, indicating that the estuary boundary lies between these two stations.

River flow volumes within the study area were reported using data from the Clyo gaging station (Figure 1-6), which has a period of record dating from 1938. Average daily flows computed over the Clyo gage period of record are shown in Figure 1-7 (USGS 2001). Figure 1-7 also includes the average daily maximums and minimums, to show the variability on a daily basis. Figure 1-8 compares flows from 1997 through October 2001 to the expected daily average flow. The daily flows have been lower than the average daily flows over the period of record (since 1938) because of an extended drought; flows in 1998 were above normal because of the El Niño weather pattern.

Defining the Salinity Gradient

Within the mixing zone, the salinity gradient is dynamic, and its location at any given point at any given time is a function of the volume of freshwater flowing downriver and tide stage (Odum et al. 1984). Salinity will advance upriver with the incoming tide and retreat downriver with the outgoing tide. Concurrently, high river flow volumes will push the salinity front downriver, while low flows will allow the salinity front to advance farther upriver.

Because the estuarine salinity gradient is dynamic, its location is more conveniently described in statistical rather than absolute terms. In a previous study of the lower Savannah River (Applied Technology & Management, Inc. 1998. Ecological study of the tidal marshes of the Savannah National Wildlife Refuge. Prepared for Georgia Ports Authority. 120 pp.), several months of field

data were collected and input to a hydrodynamic modeling to determine the location of the salinity gradient under different river flow conditions. River flows of 5900, 8200, and 9500 cubic feet per second (cfs) were considered representative of average dry season, growing season, and wet season conditions, respectively. The contours in Figures 1-9, 1-10, and 1-11 represent 50^{th} percentile salinity concentrations under each flow regime (i.e., 50 percent (%) of the time that salinity value would be located farther upriver, and 50% of the time farther downriver).

Although the estuarine salinity gradient is a continuum, a tidal marsh classification based on salinity (Figure 1-12) was developed (Odum et al.1984 and Cowardin et al. 1979). Under this classification system, tidal freshwater marshes exist in those locations along the salinity gradient where the average annual salinity is less than 0.5 parts per thousand (‰), except during periods of extended drought. Oligohaline marshes occupy the zone of 0.5 to 5.0‰, with mesohaline marshes found in the 5.0 to 18.0‰ zone. Using these criteria, the study area includes tidal freshwater, oligohaline, and mesohaline marshes.

History of the Tidewater Rice Industry Land Management Practices

The tidal freshwater conditions described above were also conducive for the development of the tidewater rice industry beginning in the mid-1700s (Richards 1859, Starnes 1886, Rice Association of Savannah 1888, Clifton 1970, and Clifton 1978, Stewart 1996). Tidewater rice production was established along restricted portions of some southeastern rivers in areas where both freshwater conditions and extreme tide range were found. These conditions were subsequently exploited by the construction of elaborate water management

systems consisting of dikes and levees, distribution canals and ditches, and water control structures. In an era prior to electric or fossil fuel driven pumps, these water management systems provided a means to move thousands of acre-feet of tidally driven freshwater efficiently onto and off of rice fields. The rice planters were in search of extremely specific conditions:

> The rice lands of the Atlantic seaboard occupy the deltas of the rivers from Pamlico Sound in North Carolina, to the St. Marys River in Georgia. They are confined in every instance to the fresh tidewater, the tidal flow being necessary for inundation, and the water, of course, must be free from salt.
>
> These narrow river strips consequently extend from the extreme limit of brackish water to the extreme limit of available tidewater, a distance varying with the volume and location of the rivers. (Starnes 1886, pg. 334)

Historical accounts of development of the tidewater rice industry on the Savannah and other southeastern rivers indicate that the existing marshes and swamps of the study area were dominated by tidal forest (see Richards 1859, Starnes 1886, Rice Association of Savannah 1888, Clifton 1970, and Clifton 1978). For example:

> The coasts of Carolina and Georgia afford a stretch of fifty miles and more of this low swamp land, which, in its primeval condition, is for the most part occupied by great, dense cypress swamps and reedy marshes. (Richards 1859, pg. 724)

These descriptions of the tidal forest are augmented by property survey maps of portions of the study area (Figures 1-13, 1-14, 1-15, and 1-16) that are clearly marked as tidal forest. In addition, field reconnaissance of the study area found that the remnant stumps of very large trees, probably cypress, are still common within the marshes and edges of the tidal creeks.

Beginning in the mid- to late-1700s, the forested swamp system began to be cleared for development of agricultural fields, which were to be planted and intensively managed for rice production. Richards (1859) described the initial step as clearing of the trees in a 50-foot swath around the future field, followed by the excavation of a ditch (during low tide) in the cleared space. The material excavated from the ditch was used to make a temporary embankment, or levee, between the ditch and river, allowing the work area to remain dry during high tide. The next step consisted of constructing a second and more substantial embankment within the newly excavated ditch. This placement allowed the second embankment to have a solid foundation clear of "roots and stumps." This second embankment, after removal of the temporary embankment, would form the exterior perimeter of the rice field.

Figure 1-17 provides a conceptualized cross-section of the main components of a typical rice field including the exterior embankment, margin ditch, and adjacent main water supply canal. Starnes (1886, pg. 335) provided dimensions of the exterior embankment (shown in Figure 1-17) as "about five feet high, with a base of ten feet and a width of four feet." The elevation of the embankment was "sufficiently high and strong to resist the encroachments of spring tides and ordinary storms." Richards (1859, pg. 726) described the dimensions of the embankments as "seven or eight feet" in height, "with base proportionate."

The area enclosed by the initial exterior embankment was subsequently cleared of trees by cutting and burning, with some larger trees simply girdled and left standing (Richards 1859). The enclosed and cleared area was subdivided,

by construction of additional embankments that checked or held the water called "check banks" (shown in Figure 1-17) into individual fields or "squares" of manageable size, averaging "seventeen or eighteen acres" (Starnes 1886, pg. 335). These acreage figures are consistent with those obtained through measurements from rectified aerial photographs (Figure 1-18) of remnant squares located on Argyle Island. Check banks had the same dimensions as the main exterior embankments (Richards 1859).

Within its confining embankment, each square was completely surrounded by a 6-foot wide, 4-foot deep "margin ditch," located 15 to 20 feet inside the exterior embankment. The rice fields within the square were further ditched with what were termed "quarter drains, . . . one and a half to two feet in depth, usually seventy-five feet apart," which served to increase the efficiency of moving water off the planted field (Starnes 1886, pg. 335).

Fields were held dry for planting and harvesting. Water was moved on and off the fields at various times during the growing season to accommodate different growth stages of the rice plants, or to control weeds and insects. The water source for flooding the rice fields was the main river channels. Water was conveyed from the rivers to each square by a system of main canals excavated through the former tidal forest (Starnes 1886, pg. 335). Main canals were 20 feet in width and 5 feet in depth and were fitted with a floodgate at their connection points with the main river. These floodgates were frequently constructed as locks to allow boat navigation between the river and the main canals.

The margin ditch on the interior of a square was connected to the main canal on the exterior of a square via a wooden "trunk" that allowed the water

level in a square to be controlled independently (Starnes 1886, pg. 335). The trunk, essentially a wooden culvert, was positioned through the levee, connecting the interior margin ditch to the larger main canals. The trunk was fitted at each end with height adjustable wooden flap gates and riser boards that provided control of water flows and levels. When open, the flap gates allowed the enclosed rice field to be either flooded during high tide or drained during low tide. When closed, the flap gates allowed the rice field to be kept either dry or flooded as necessary.

Clearing of the tidal swamp and development of the rice fields occurred over a number of years, as indicated by a series of historical maps (Figures 1-13 through 1-16). The McKinnon map of 1796 (Figure 1-13) showed that large tracts on Argyle Island had already been cleared for rice fields, although extensive tidal forest still remained. Figure 1-14 provides a later (probably c. 1840) map of the portion of Argyle Island contained within the looping meander on the lower right quadrant of the 1796 map (Figure 1-13). This looping meander is also prominently depicted along the right side of the 1999 aerial photograph in Figure 1-18. Note that portions of this area had been cleared and planted in 1839 and 1840, but that a substantial tract remained "In Wood" in 1840. This same area was also included in the Manigault map of 1867 (Figure 1-16), but had been entirely cleared of forest by that time, providing a time frame for clearing of the study area between 1840 and 1867. The C. de Choiseul map of 1846 (Figure 1-15) clearly showed area cleared on northern Argyle Island accomplished to that date, as well as the remaining tidal forest. The C. de Choiseul map of 1846 (Figure 1-15) confirmed that clearing of the study area

occurred around mid-1840. Wilms (1972, pg. 55) stated "the period from 1840 to 1860 marked Georgia's 'golden age' of rice production, and it was probably at this time that the maximum amount of tidewater lands was in rice production."

Land-Cover Changes Associated with the Post Tidewater Rice Industry Era

Historical maps and descriptions of the development of the former rice fields allow a timeframe to be placed on the clearing of the former forested swamps. More difficult, however, is placing a timeframe on when the rice fields were abandoned, and how long the marshes have had to develop into their current state. Prior to the Civil War, millions of pounds of rice were shipped annually through the Port of Savannah. However, the war resulted in the destruction of much of the rice production infrastructure developed over the preceding century. After the Civil War, the rice industry never regained its pre-war production capacity and went into a prolonged decline. Although the last rice harvest occurred in the early 1900s, rice production began decreasing in the late 1800s (Clifton 1970, Stewart 1996).

Several factors have been blamed for the demise of rice production in Georgia including the number of tropical storms and hurricanes at the turn of the century, competition from rice plantations in Arkansas, Louisiana, and Texas, and the inability to use heavy equipment on the unconsolidated soils (Clifton 1970). Plantation records kept by the Manigault family of their two plantations on Argyle Island document that rice was produced on portions of the island through at least 1889, at which time plantation records ceased (Clifton 1978). Granger (1937) noted that rice continued to be planted on the adjacent Ursla Island (Ursla

Island) until approximately 1900. At that time, planting was abandoned on both Isla Island and Argyle Island because they were

> ruined for agricultural purpose when the construction of jetties by the United States Government in the south channel of the Savannah River about 1892 so deepened the channel as to render control of the flow over the rice fields impossible. (Granger 1937, pg. 89)

The inability to control water in the rice fields dealt the final demise of the remnants of the rice industry. "Dredging of the Savannah River eventually led to brackish water entering the rice fields and destroying the crop. By 1910, there were no attempts to cultivate rice" (Wheeler 1998, pg. 118).

Most of the area that constitutes the study area was incorporated into the Savannah National Wildlife Refuge in the 1930s. Many of the former rice fields were not completely abandoned but have been managed for migrating waterfowl since the 1930s when the wildlife refuge was established. However, much of what had been dense tidal forest in the early 1700s had been cleared, hydrologically altered through construction of ditches and embankments, intensively managed for agricultural production for approximately 150 years, and then abandoned.

Starnes (1886, pg. 335), in his description of tidewater rice plantations, calculated that a fully developed 640-acre tidewater rice plantation might have had in excess of 18 miles of embankments. The combined embankments and ditches would sum to over 118 miles, representing some 317,000 cubic yards of excavation for a typical 640-acre tidewater rice plantation. Such intensive diking and ditching, in addition to the loss of the sediments, has served to alter the environmental gradients that had given rise to the tidal forests completely.

The current vegetation cover is the result of the environmental conditions that have become established since the time of rice field abandonment. The remnants of the rice fields' water-management systems persist to this day as evidenced by the physical presence of trunks, ditches, and canals observed during field work conducted for this study.

Tidal Creek Development

The abandonment of the rice fields after the demise of the tidewater rice industry also meant the end of ditch and embankment maintenance, which had been a constant struggle throughout the rice-growing era. "The ditches are cleaned out annually, as they foul quite rapidly from abrasion, silt, and water vegetation (Starnes 1886, pg. 336). Figure 1-19 provides aerial photographs from 1952 and 1999 of a portion of Argyle Island. The remnants of the main canals, margin ditches, and embankments are clearly visible and account for the regular "checker board" pattern.

The extent of the changes that have occurred in the remnant canal and ditch systems of the former rice field squares is illustrated by comparison of the 1999 aerial photography with historical aerial photographs from 1952 (Figures 1-20, 1-21, and 1-22). Changes at three locations are compared, indicated as A, B, C on Figure 1-19.

In 1952, the parallel configuration of the margin ditches was still clearly discernable at Location A (Figure 1-20). The parallel ditch arrangement reflects the design that included an embankment between each square, with a margin ditch constructed within each square near the base of the embankment. As the images are rectified to state plane coordinates, distances between objects

depicted on them may be measured. The centerlines of the parallel ditches range from 42 to 47 feet apart. This distance is generally consistent with the dimensions of embankments and margin ditches provided by Starnes (1886).

At Location B in 1952 (Figure 1-21), one set of parallel margin ditches (east-west orientation) intersects with a north-south oriented section of a main canal. By 1999, the north margin ditch had become filled with sediment and overgrown, its alignment discernable only by the vegetation signature. No substantial changes in the north-south canal are evident.

In 1952, Location C (Figure 1-22) still had not only remnant margin ditches, but remnant quarter drains as well. The quarter drains extended perpendicularly from the margin ditches. The quarter drains were generally gone by 1999, their former locations detectable via vegetation signatures. Quarter drains were "one and a half to two feet in depth, usually seventy-five feet apart" (Starnes 1886, pg. 335).

Marsh Substrate Development

Starnes (1886, pg. 334) described the swamp sediments in which the rice fields were constructed as

> pure alluvium in formation. . . The soil, in many cases, is ten, twenty, or even thirty feet in depth to the underlying stratum of sand. Often the remains of prostrate forests, the result of ancient hurricanes, with layer of ashes and Indian remains, lie buried in the alluvium, the logs and stumps frequently so near the surface as to present a serious obstacle to the ditcher, and greatly enhancing the cost of reclamation.

Pennington (1913, pgs. 13 and 7, respectively) described the rice field soil as "moist, dark brown soil, too deep for comfort" with "blue clay which the sun bakes like a brick." In addition, the sediments of the tidal forest, which then made up

the rice field, seem to have been subject to consolidation and oxidation as a result of cultivation

> the drains imperatively require to be not only thoroughly excavated in the origin, but to be constantly kept down to their original depth, and, as the land settles, to be lowered to the same relative depth. (Starnes 1886, pg. 335)

Heyward (1937, pg. 27) remarked

> The fertility of the soil, after years of planting, with little or no fertilizer, gradually lessened, and the level of the fields sank slightly from year to year. It has been estimated that through a period of a century and a half the rice fields of South Carolina and Georgia sank fully a foot, and perhaps more.

The soil survey for Bryan and Chatham Counties, Georgia (USDA 1974), only briefly describes the soils of the former rice fields but states that if the marsh is kept dry for an extended period, the surface will rapidly subside.

Figure 1-17 provided a conceptual cross-section of the embankment and margin ditch of a typical rice field square as it may have looked during the tidewater rice era. The horizontal dimensions are based on descriptions of Starnes (1886) and Richards (1859). The main water supply canals were approximately 20 feet in width and contained by the 10-foot bottom width perimeter embankments. The margin ditch is located in the rice field interior about 15 or 20 feet inside the perimeter embankment. The main water supply canals are connected to the margin ditches via the rice trunks. Flap gates fitted at each end of the trunk control water flow through the trunks.

The historical vertical elevations in Figure 1-17 reflect deductions based on Global Positioning System (GPS) derived elevations of currently existing

conditions. For instance, remnant rice trunks, exposed during low tides, still protrude from the bases of the former embankments at a number of locations.

During the time of historical operation, these trunks extended beneath the embankments, connecting the main water supply canals and river channels with the margin ditches inside the square. The bottom elevation of the trunks was set so that at low tide the water flooding a square could be completely drained into the margin ditch and out the trunk. The elevations of four remnant trunks were determined using GPS survey (Table 1-1).

Table 1-1. Locations and bottom elevations of four remnant rice trunks.

Trunk	Easting (ft NAD83)	Northing (ft NAD83)	GPS Elevation (ft NGVD29)	Comments
1 – Little Back River	979800	799414	-0.37 (top)	14 inches thick
2 – Little Back River	981286	799102	-0.74 (top) -2.2 (bottom)	Riverward end of trunk angled slightly downward
3 - North tip of Argyle Island at confluence of Middle River and Little Back River	975100	805930	0.0 (top)	This trunk is in excellent condition with flap gates still attached and in working order. It was probably installed fairly recently.
4 - Front River, near north tip of Ursla Island	970909	804442	-0.33 (top)	Constructed with hand-forged iron nails.

ft NAD83 = feet North American Datum 1983
ft NGVD29 = feet National Geodetic Vertical Datum 1929
GPS = Global Positioning System

The trunks still had thick (approximately 2-inch thick) wooden planking attached on both top and bottom. The sides appeared to consist of single pieces of lumber, set on edge, with what today would be considered a non-standard size of 2 by 14 inches. The top and bottom planking was attached to the sides by either wooden pegs or, in one instance, hand-forged iron nails. While some

measurements were of the tops of the trunks, assuming an approximate vertical dimension of 14 inches, the bottom invert elevations would range from approximately -1.5 to -2.3 feet (Table 1-1).

Additional information regarding historical topographic elevations within former rice fields was obtained by survey of former rice fields that were never fully abandoned and left to the ravages of the tide. As most of the project area is within the Savannah National Wildlife Refuge, there are a number of the former rice-field squares that have been maintained for waterfowl management since at least the 1930s. These "duck-impoundments" have had their dikes maintained and are regularly drained and planted with forage crops for consumption by migrating waterfowl (Gordon et al. 1989, Kovacik 1979). Accordingly, these managed impoundments have not had the sediment accumulation found in the tidally inundated marshes that now occupy much of the abandoned rice fields and, therefore, may serve as an indicator of bottom elevations of the rice fields.

GPS survey of these areas found ground elevations within the managed impoundments of 0.1 to 0.6 feet. These elevations would be consistent with the elevations determined for the trunks, which would have been set slightly lower than the surface elevation of the rice field. In addition, the ground elevations found in the managed impoundments are considerably lower than the surface elevations of the adjacent abandoned rice fields that have reverted to marsh. The surface elevations of non-impounded marsh adjacent to the impounded areas that were surveyed ranged from 4.0 to 4.4 feet, indicating, that in these areas, some 4 feet of sediments had accumulated within the former rice field squares.

Other Anthropogenic Perturbations

In addition to the extensive water management systems constructed for the tidewater rice industry, a number of other alterations to the river system have occurred over the years since the removal of the tidal forest. On a landscape scale, beginning with the initial settlement of the colonies of Georgia and South Carolina, the old-growth upland forests throughout the Savannah River drainage basin were cleared for forest products and agriculture (Stewart 1996). This would have had the effect of greatly increasing the sediment load carried downriver to the estuarine delta and probably increasing the inorganic composition of the sediment.

Construction of three major dams along the river also affected river flows and downriver sediment transport (USACE 2002). The J. Strom Thurmond Dam, completed in 1954, was the first USACE flood control project constructed in the Savannah River Basin and is located near the City of Augusta at approximately river mile 240. This dam is "credited with reducing the amount of sediment carried by the river into Savannah Harbor by 22%" (USACE 2002). Two other dams are located further up the river, the Richard B. Russell Dam (approximate river mile 277) completed in 1984 and the Hartwell Dam (approximate river mile 307) completed in 1963 (USACE 2002).

Additional perturbations to the study area are associated with the continuing development of the Port of Savannah. Table 1-2 provides a summary of the dredging projects impacting the Savannah River.

The port has been operating since the initial founding of the City of Savannah during the colonial era. Port development began in earnest though in

the early 1800s with development of the "steam-dredging machine" (Rowland 1987, pg. 132).

Table 1-2. Summary of dredging projects impacting the Savannah River.

Date	Description of Project
1733-1850	Various projects, work done when necessary to maintain channel
1873 –90	Channel 22 feet deep at mean high water (MHW) by building a dam at the Cross Tides
1907-10	Channel 26 feet from the Quarantine Station to the Seaboard Rail Line Bridge
1912	Channel 21 feet from the Seaboard Rail Line Bridge to the foot of Kings Island
1917	Channel 30 feet from the sea to Quarantine Station
1927	Consolidation of projects related to Savannah Harbor, channel 30 feet deep 500 feet wide from the sea to the Quarantine Station, 26 feet deep 400 feet wide to the Seaboard Rail Line Bridge, 21 feet deep 300 feet wide to Kings Island and dredging Drakies Cut.
1930	Channel 26 feet deep and 300 feet wide from the Seaboard Rail Line Bridge to the foot of Kings Island
1945	Deepening the channel and turning basin above the Seaboard Rail Line Bridge
1946	Extending the channel upstream to a point 1500 feet below the Atlantic Coastal Highway bridge, construct turning basin at upper end
1954	Deepening the channel to 34 feet and widening to 400 feet in the vicinity of the American Oil Company Refinery wharf to the Savannah Sugar Refinery, with improvement to the turning basin
1962	Enlargement of the turning basin near Kings Island
1965	Various dredging project including deepening the bar channel and channels by the wharf and refineries, construct tide gate structure across the Back River, construct drainage canal across Argyle Island 15 feet deep and 300 feet wide, control works and canals for supplying freshwater to the Savannah national Wildlife Refuge
Early-1970s	Dredging of McCombs Cut, excavation on New Cut, construction of the tide gate
1976	Modification to turning basins
1984	Construct three new work curve wideners in the inner harbor channel
1986	Under the Water Resources Development Act (WRDA) Savannah Harbor widening from Fig Island Turning Basin to Kings Island Turning Basin
1991-92	Filling/closure of New Cut, removal of the tide gate
1992-94	Deepening 31 miles of harbor to 42 feet MHW

Source: Applied Technology & Management, Inc. 2001. Tidal amplitude study. Prepared for Georgia Ports Authority. 37 pp.

The Savannah Harbor project began in 1826, and the steamer *Metropolis* arrived in Savannah to begin dredging in 1829 (Rowland 1987). Dredging

facilitated deepening of the navigation channels and manipulation of the course of the river. The events summarized in this table show that dredging of the Savannah River occurred almost continuously for more than 150 years since the mid-1800s. Major dredging projects of the port continued recently with the deepening of the port to 42 feet below mean high water (MHW) in 1992-94.

Several river oxbows were dredged to facilitate river flows. Drakies Cut was dredged in the 1927 and McCombs Cut in the 1970s (Figure 1-23). Recent projects that had great impact were the excavation of New Cut and construction of the tide gate (1970s), decommissioning of the tide gate (1991), closure/filling of New Cut (1992), and the deepening of the navigational channel (1992-94). New Cut connected the Back River with the Middle River and has been opened and shut more than once.

In the early 1970s, the USACE constructed the Savannah River tide gate across the Back River. The purpose of this structure was to reduce the need for maintenance dredging of the shipping channel within the Front River by increasing the scour along the river bottom. To accomplish this, the tide gate was opened during an incoming tide and then closed at high slack tide, just before the tide began to recede. Closing the tide gate had the effect of impounding a huge volume of water in the Back River that, to escape as the tide dropped, was rerouted through New Cut into the shipping channel in the Front River. The extra water volume in the Front River increased the current velocity and scour, reducing the need for maintenance dredging.

The tide gate had the unintended consequence of displacing salt water 2 to 6 miles upriver (Pearlstine et al. 1993). During its period of operation from

1974 through 1992, the tide gate is credited with destroying 74% of the tidal freshwater marshes of the Savannah River (Pearlstine et al. 1990). At the request of the U.S. Fish and Wildlife Service, the tide gate was removed from operation in 1991-92 (Latham and Kitchens 1996 and Applied Technology & Management, Inc. 1998. Ecological study of the tidal marshes of the Savannah National Wildlife Refuge. Prepared for Georgia Ports Authority. 120 pp.).

Sea-Level Rise

The National Ocean Service maintains an extensive network of tidal gaging stations including the Ft. Pulaski gage (Station No. 8670870) near the mouth of the Savannah River (National Ocean Service 2002). This gage has collected continuous tide stage data since 1 July 1935 and has the longest period of record for any of the water level gages in the study area (Figure 1-24). A tide gage must be vertically stable for at least 40 years to be a valid gage for estimating relative sea-level rise (Dean and Dalrymple 2001).

Figure 1-25 provides the data from the Ft. Pulaski gage plotted as the annual mean water level. Data from 1973, 1974, and 1990 were not included because data was recorded less than 50% of the time during those years. The graph shows a definite increase in relative sea level with the equation of the trend line indicating an annual increase of 0.0102 feet or 1.02 feet per century.

Based on the Ft. Pulaski data, Hicks et al. (1983) reported a 0.008 feet per year relative sea-level rise between 1940 and 1980. Hicks et al. (1983) states this relative rate of sea-level rise includes 0.002 feet of crustal rebound related to glaciation in the last ice age, 0.003 feet of change in ocean volume due to warming, and a residual of 0.0001 inches that remains unexplained.

The Savannah area has been subject to substantial land subsidence resulting from groundwater withdrawals and subsequent decline in hydraulic head (Davis 1987). This subsidence must be accounted for in order to have a reliable estimate of relative sea-level rise. However, precise surveys by the National Ocean Service have shown the Ft. Pulaski gage to be a consistent, reliable indicator of relative sea-level rise over the period 1940 through 1980 (Davis 1987).

Davis (1987) discussed the extent of land subsidence in Savannah. In his review, he noted that pumping wells for municipal and industrial water supplies began in 1887. Water withdrawals were accompanied by artesian head declines and subsidence. The subsidence was attributed to the settling of fine-grained sediments in the aquifer, with most of the subsidence occurring after 1933 when pumping rates were substantially increased. The area of highest pumping and subsidence identified by Davis (1987) overlaps with the southern portion of the study area (Figure 1-26).

Based on Davis (1987), potential ground subsidence in the study area between 1955 and 1975 ranged from approximately 0.049 feet at the northern end of Argyle and Ursla Islands to more than 0.26 feet near the most downriver portion of the study area. Subsidence continues at rates of 0.002 to 0.013 feet per year at these locations (Davis 1987). These rates translate to an additional 0.054 feet of subsidence at the northern end of Argyle and Ursla Islands, and an additional 0.29 feet of subsidence at the southern end of these islands. In total, the northern end of the study area has been potentially subjected to 0.10 feet of subsidence since 1955, with the southern end experiencing a total of 0.55 feet.

Literature Review

Brewer and Grace (1990) characterized oligohaline marsh community structure in Louisiana. Their study area included distinct vegetative zonation correlated to distance upriver from the brackish Lake Pontchartrain, with the most salt tolerant species being found closest to the lake. The vegetative zonation was not correlated with average soil salinity and was instead attributed to infrequent, storm-generated salinity pulses that would temporarily raise soil salinities. The salinity driven upriver by the storm events would attenuate with distance, resulting in the observed plant zonation. Since the salinity pulses were temporary, soil salinities would decrease to their former lower levels. Their study did not address the sediment salinity levels generated by the storm pulses, the duration of elevated salinity, or the amount of time required for sediment salinities to drop to their previous levels; however, the salt pulses were characterized as short-term. Salt tolerant species that temporarily flourished as a result of the salt pulses would be gradually replaced by less salt tolerant, but more competitive, species as the time between salt pulses increased; however, the authors suggested this replacement would occur over a time scale of years or decades, not seasons.

Howard and Mendelssohn (2000) conducted a greenhouse study of oligohaline marsh community structure that examined the interaction of salinity exposure and water depth. A 3-month salinity exposure at 12‰ with concurrent flooding to either 1- or 15-cm resulted in community changes. Changes did not occur with only 1-month salinity exposure.

Perry and Hershner (1999) studied temporal shifts in vegetative dominance over a 14-year period in tidal freshwater marshes on Chesapeake Bay. Average yearly salinity at the site was approximately 0.45‰ and ranged from 0 to 7‰. The study found an increase in oligohaline-associated species, particularly *Spartina cynosuroides*. An increase in oligohaline conditions was attributed to a relative sea-level rise of 4 mm per year. Perry and Hershner (1999) cited the need for studies on the inundation frequency and salt tolerance of individual species in order to predict the rate at which community changes would occur in response to increasing salinity.

Pearlstine et al. (1990), Latham (1990), Latham et al. (1991), Latham et al. (1994) reported various aspects of a previous vegetation study of the tidal freshwater and brackish marshes of the Savannah National Wildlife Refuge. This study, most comprehensively described in Pearlstine et al. (1990) and Latham (1990), examined the effects of tide gate operation on marsh vegetation distributions along the salinity gradient on the Little Back River and Back River. According to this study, tidal freshwater marshes existed downriver to the tide gate and were replaced by brackish vegetation assemblages as a result of tide gate operation. The study was initiated in 1985, 8 years after the tide gate began to operate in 1977, and found the existing vegetation distributions to be correlated with sediment salinity, distance from river channels and tidal creeks, and ground elevation. The goal of the study was to predict vegetation changes that would occur after removal of the tide gate and the subsequent return of sediment salinity to levels conducive to the reestablishment of tidal freshwater

marsh. The study concluded that reestablishment of tidal freshwater marsh would occur rapidly after sediment salinities decreased to below 0.5‰.

Latham and Kitchens (1996) reported the successful reestablishment of freshwater vegetation after the tide gate was removed in 1992. Effects of the tide gate are discussed in detail in Pearlstine et al. (1993). During the time the tide gate was operating, Latham et al. (1994) found the change from freshwater to brackish vegetation along the lower Savannah River to be related strongly to the salinity gradient. However, their study was not sufficient to explain vegetative distributions within freshwater areas and suggested interspecies competition to be a primary factor.

Many studies have been conducted on salt marsh vegetation (see Montague and Wiegart 1990 for a comprehensive review). The salt tolerance of plants under laboratory or greenhouse conditions has also been studied extensively. Broome, et al. (1995) conducted a greenhouse study of Louisiana marsh plants and *Scirpus olneyi* to determine the effects of salinity and water depth on these two species. Based on their results, salinity greater than 10‰ reduced growth of both species, but *Scirpus olneyi* was more affected than *Spartina patens*. Increased flooding depth reduced growth of *Spartina patens*, but had little effect on *Scirpus olneyi*. Baden et al. (1975) cited salinity as the primary factor in the distribution of vegetation in abandoned rice fields in South Carolina. Allen et al. (1997) conducted a greenhouse study of baldcypress seedlings in Louisiana and concluded that increasing salinity reduced leaf biomass more than root biomass. Flowers et al. (1977) studied mechanisms by which the naturally occurring halophilic flora survive, including growth, uptake,

and accumulation of salt. The effects of increased water depths (up to 0.5 feet) on *Sagittaria lancifolia* were studied with little or no impacts to the plants (Howard and Mendelssohn 1995). Howard and Mendelssohn (2000) also conducted greenhouse experiments using pulsing salinities on oligohaline marsh plants and found that duration of salinity exposure and water depth determined whether existing vegetation recovered or new species were established.

In studies conducted by Baldwin and Mendelssohn (1998), oligohaline plants *Spartina patens* and *Sagittaria lancifolia* were not significantly affected by flooding or salinity unless "disturbance" (clipping of aboveground vegetation) occurred.

Visser et al. (1999) studied development impacts to oligohaline marsh associated with the Atchafalaya River of Louisiana using 5 permanent vegetation stations surveyed over 24 years. Cluster analysis of vegetation data was conducted using two-way indicator species analysis (TWINSPAN). Johnsson and Moen (1998) discussed the effects of belt transect size when establishing vegetation sampling plots.

Kent and Coker (1992) defined a plant community as the collection of plant species growing together in a particular location that show a definite association or affinity with each other (i.e., they are found growing together in certain locations and under certain environmental conditions more frequently than would be expected by chance). The plant association is the reflection of the environmental conditions, or collection of environmental factors, that define the living requirements, or restrictions, under which the association is found. In the case of the tidal freshwater and oligohaline marshes of this study, these

environmental factors include, but are not limited to, salinity and the hydrologic parameters of flood depth, duration, and frequency.

As commonly depicted in plant ecology literature (see Whittaker 1975, Gauch 1995, Kent and Coker 1992, Jongman et al. 1995), the abundance of an individual plant species along a gradient of a single environmental factor can hypothetically be plotted as a Gaussian curve. Under the hypothetical curve, also called a unimodal model, species abundance increase along the gradient to some peak level and then begins to decline as the intensity of the factor increases to a point where it induces stress and ultimately intolerance in the plant. This type of response prevents analyzing for a direct linear correlation of plant abundance with an environmental factor. A positive correlation may be found along one portion of the gradient, and a negative correlation along another.

Additionally, the abundance of a single plant species at a particular location is usually the integration of multiple gradients acting simultaneously (Kent and Coker 1992). Acting alone, each gradient would induce an abundance response curve unique to a particular plant species. However, under actual conditions, the abundance of an individual plant species at a belt transect is dependent on the belt transect's position in relation to all the gradients; with some gradients exerting more influence than others. Consequently, the abundance of a species at a particular location can be thought of as the intersection of all the individual response curves for that species for all the environmental factors that define the habitat at that location. For this reason, plant community data are multivariate and not subject to analysis by linear regression (Kent and Coker 1992).

As a mulitivariate technique, ordination identifies relationships between species distributions and the distributions of associated environmental factors and gradients (Kent and Coker 1992). Indirect ordination techniques, particularly detrended correspondence analysis (DCA), use only species abundance data and determine the existence of species association patterns within that data. Plots produced by DCA group species according to the strength of their association with one another and separate the groups along one or more gradients. However, these gradients represent only underlying patterns derived from the plant species data and are only indirectly associated with an actual environmental gradient through inference by the researcher.

Detrended canonical correspondence analysis (DCCA) is a direct ordination technique because it simultaneously considers both species and environmental data (Kent and Coker 1992, Jongman et al. 1995). DCCA allows the relative importance of the different environmental variables to be assessed by determining what combination of the environmental variables best explains the species variation.

Hypothesis and Approach

Vegetation distributions along the river channels of the upper Savannah River estuary display distinct zonation that previous studies (Latham 1990, Pearlstine et al. 1990) have attributed to salinity. The objective of this current study is to characterize the spatial and temporal differences in the salinity and tidal gradients between the Front, Middle, and Little Back Rivers, including the influence of the tidal creek system on distributing salinity across the marsh surface. The hypothesis to be tested is that substantial differences in salinity are

normally present across the marsh surface and within the marsh sediments, differences that are manifested in plant species associations present at any location within the marsh. An unknown factor to be explored is the variability of sediment salinity at a given location. Salinity levels within the river channels and high tide flood waters are highly variable, depending on river flow volumes and tide stage. However, since salinity effects on marsh plant physiology are largely manifested through the roots, it is the salinity within the sediments surrounding the plant roots that is the driving factor in plant distributions. Because plant distributions are generally relatively stable in the absence of major anomalous disturbances, it is hypothesized that sediment salinity has less variability than the highly variable salinity found in the adjacent tidal surface waters and that the sediment salinity represents an integration of the surface water salinity variability. However, under what circumstances are transient sediment salinity increases generated, how long do they persist, and what effect may they have on the overlying vegetation assemblages? Is short-term variability of salinity levels within the marsh sediments more important in affecting plant species distributions than long-term trends in sediment salinities?

The project approach involves simultaneous measurements of salinity and water levels at representative locations across the marsh to determine any spatial differences that may be expressed as ecological gradients. Figure 1-27 provides a conceptual approach to a sample design that allows salinity in the river channels to be linked to salinity in marsh sediments, where the physiologic effects to plants originate. In Figure 1-27, the source of salt within the marshes is the ocean salinity carried up the river channels by the rising tide. The salinity

gradient develops from the interplay of river flow volume and tide stage. While the river channels overflow their banks during high tide, flooding the marsh, the tidal creek system greatly increases the interface between the open water and the vegetated marsh. In addition, the tidal creeks serve as a conduit for saline waters from a specific reach of a river channel to be transported across a disproportionate area of marsh surface. Analysis of the gradients for their influence on vegetation distribution requires seasonal vegetation monitoring at established locations. Vegetation monitoring allows plant species abundance and population structure to be described quantitatively and over time.

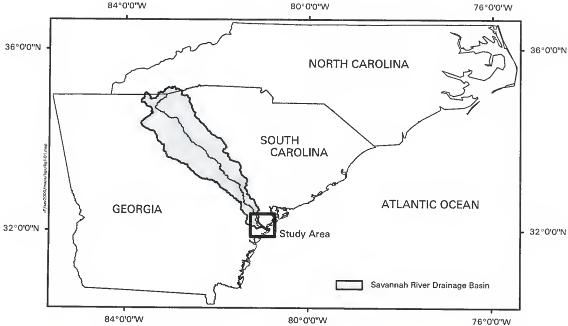


Figure 1-1. Regional map of Savannah River drainage basin with study area.

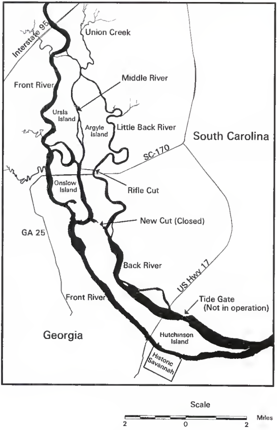


Figure 1-2. Project study area.

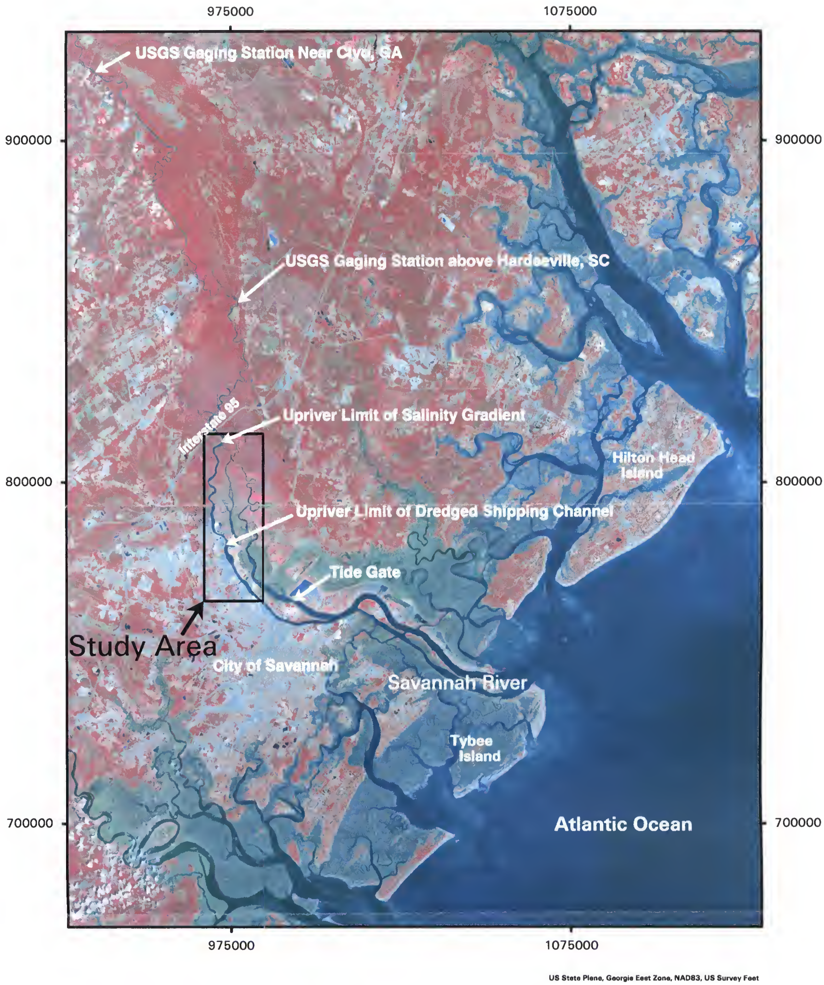


Figure 1-3. Landsat 7 satellite image showing extent of Savannah River estuary.

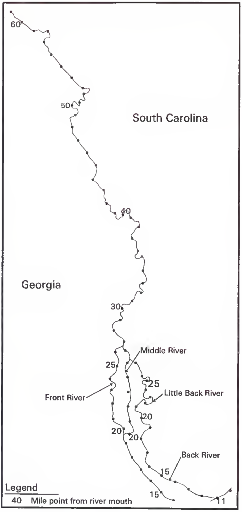


Figure 1-4. Savannah River miles.

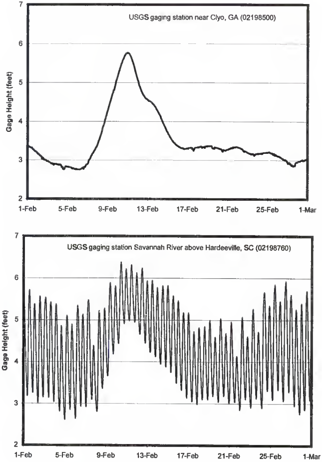


Figure 1-5. Comparison of gage heights at the USGS gaging stations at Hardeeville, SC and Clyo, GA during February 2002 showing loss of tidal signal between the two stations.

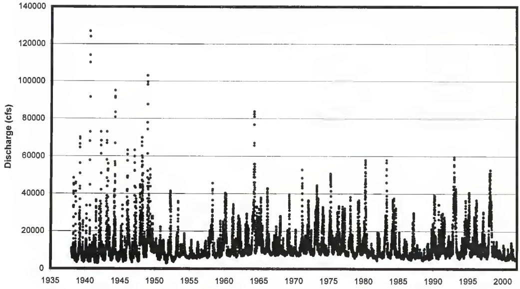


Figure 1-6. Flow volumes of the Savannah River recorded at the USGS gaging station near Clyo, GA (02198500) for the period of record, 1938 through October 2001.

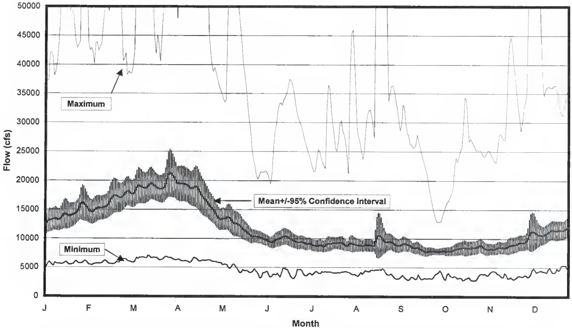


Figure 1-7. Average daily flow (cubic feet per second) of the Savannah River as recorded at the USGS gaging station near Clyo, GA (02198500) during the period of record, 1938-1999.

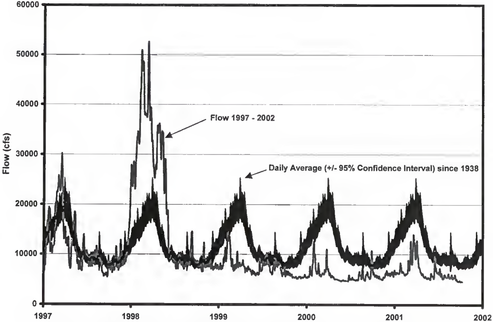


Figure 1-8. Recent average daily flow (cubic feet per second) of the Savannah River compared to the average daily flow for the period of record (1938 to present) at the USGS gaging station near Clyo, GA (02198500) from 1997 through October 2001 .

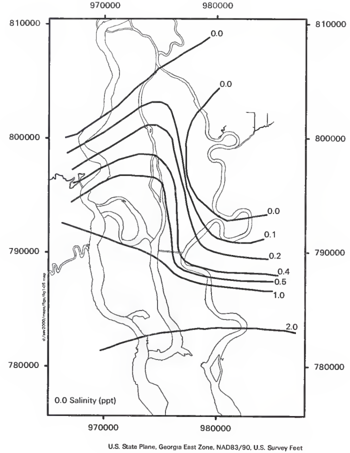


Figure 1-9. Typical growing season salinity probability contour at river flow of 8,200 cfs. Contours represent location of 50th percentile salinity gradient when tide stage is above 4.5 feet.

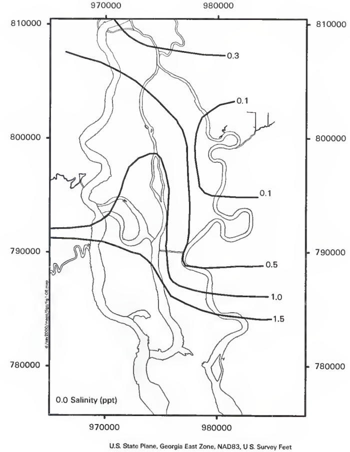


Figure 1-10. Typical dry season salinity probability contour at river flow of 5,900 cfs. Contours represent location of 50th percentile salinity gradient when tide stage is above 4.5 feet.

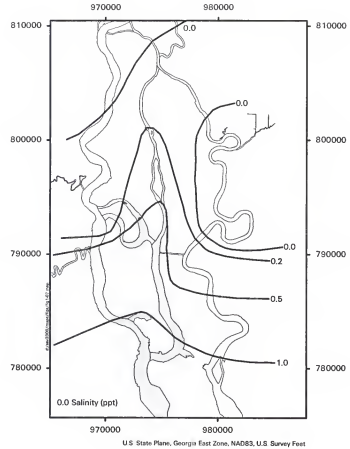


Figure 1-11. Typical wet season salinity probability contour at river flow of 9,500 cfs. Contours represent location of 50th percentile salinity gradient when tide stage is above 4.5 feet.

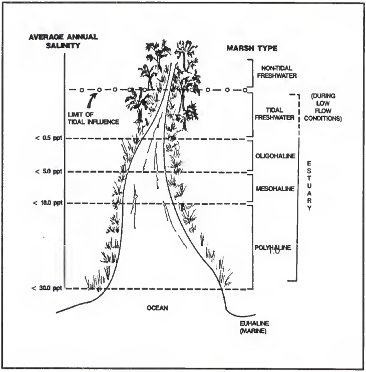


Figure 1-12. Conceptual schematic of tidal marsh classification based on salinity (after Odum et al. 1984 and Cowardin et al. 1979).

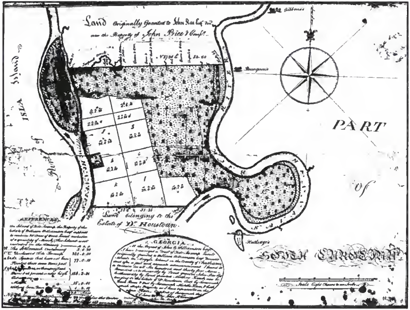


Figure 1-13. Historical map (1796) of a portion of Argyle Island drawn by John McKinnon. (Courtesy of the Georgia Historical Society).

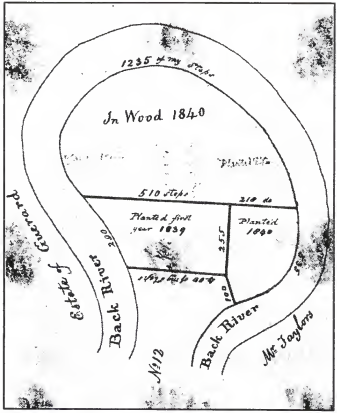


Figure 1-14. Historical map (c.1840) of a portion of Argyle Island. The map is oriented with north to the left. The original map is drawn in the margin of an accounting ledger in the Manigault Plantation Records, Southern Historical Collection, University of North Carolina at Chapel Hill.

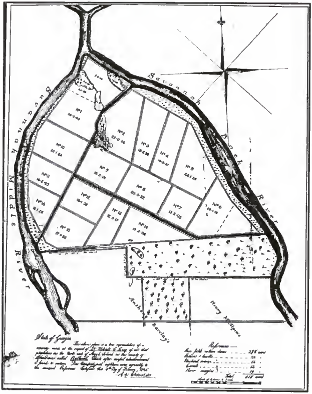


Figure 1-15. Historical map (1846) of Redknoll Plantation on the northern portion of Argyle Island drawn by C. de Choiseul. (Courtesy of the Georgia Historical Society)

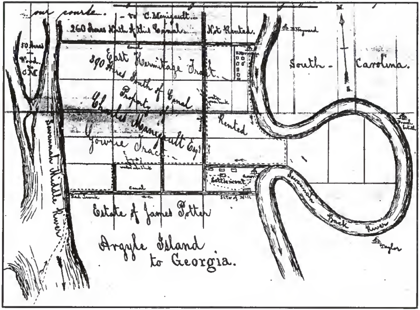


Figure 1-16. Historical map (1867) of the Gowrie and East Hermitage Plantations on Argyle Island drawn by either Charles or Louis Manigault. The original map is contained within the Manigault Plantation Records, Southern Historical Collection, University of North Carolina at Chapel Hill.

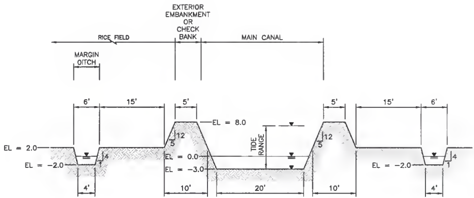


Figure 1-17. Conceptual cross-section of typical rice field water management system.

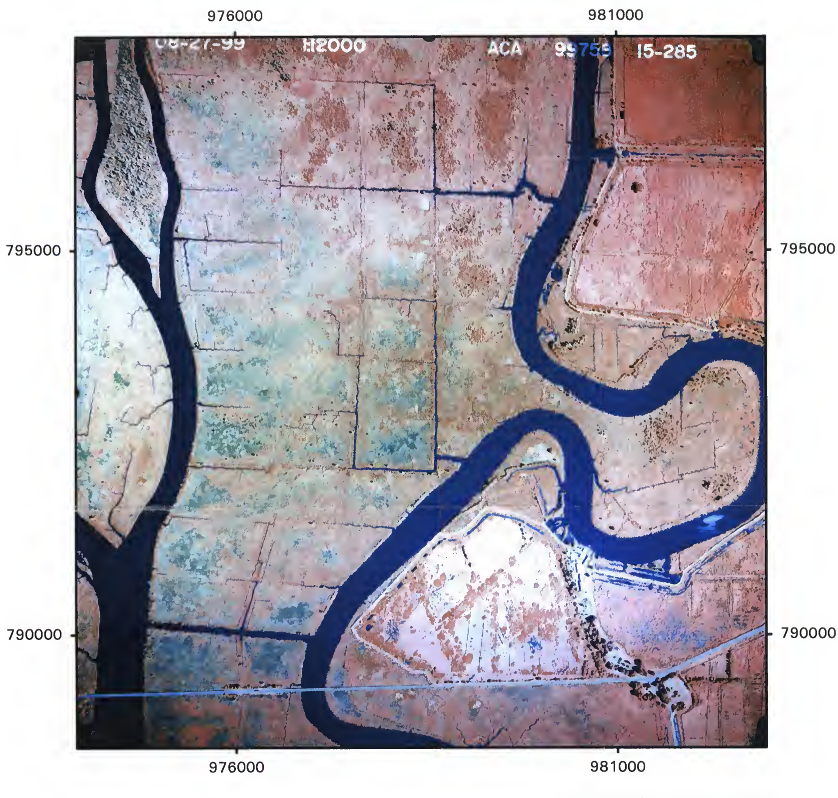


Figure 1-18. Infrared aerial photograph (1999) of a portion of Argyle Island.

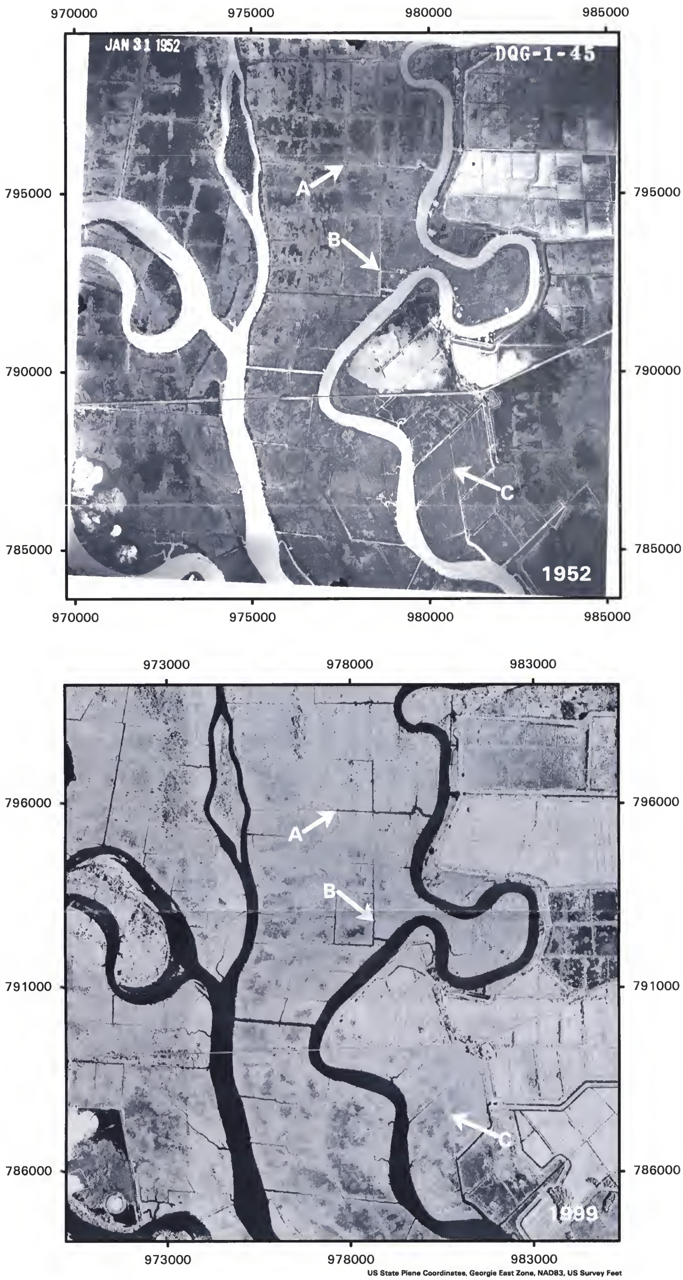


Figure 1-19. Aerial photographs (1952 and 1999) of a portion of Argyle Island with locations of margin ditch change analyses labeled as A, B, and C. The change analysis is detailed in Figures 1-20, 1-21, 1-22.

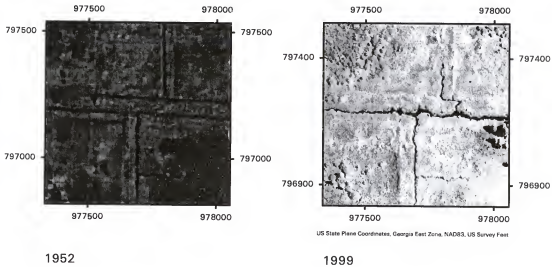


Figure 1-20. Location A change analysis of margin ditches (as noted on Figure 1-19).

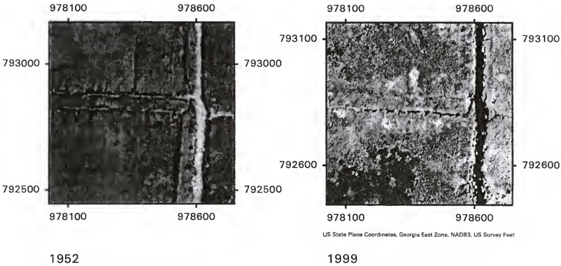


Figure 1-21. Location B change analysis of margin ditches (as noted on Figure 1-19).

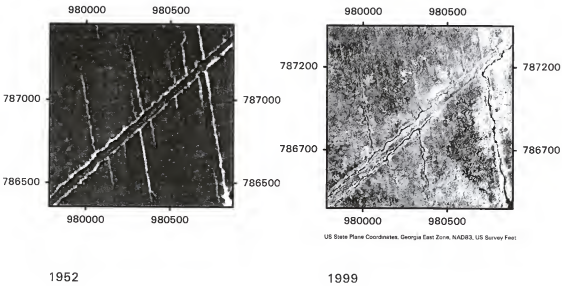


Figure 1-22. Location C change analysis of margin ditches (as noted on Figure 1-19).

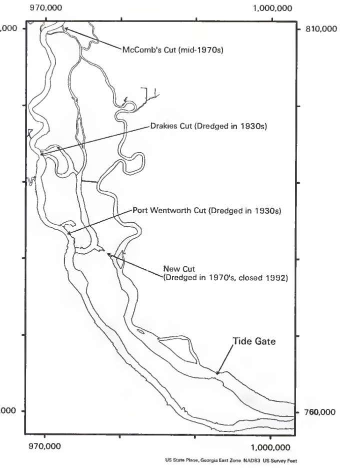
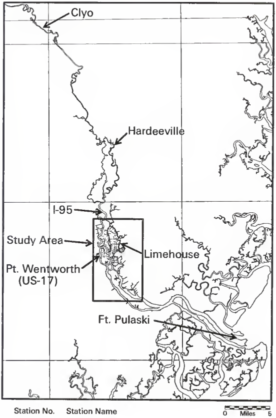


Figure 1-23. Channel modifications affecting downriver freshwater flow and upriver salinity transport.



Station No. Station Name

US Geological Survey Stations

02198500	Savannah River near Clyo, GA
02198760	Savannah River above Hardeeville, SC
02198840	Savannah River (I-95) near Pt. Wentworth, GA
02198979	Little Back River (Lucknow) near Limehouse, SC
02198920	Savannah (Front) River (US-17) near Pt. Wentworth, GA

National Ocean Service Station

8670870	Ft. Pulaski, GA

Figure 1-24. Tide gage locations on the lower Savannah River.

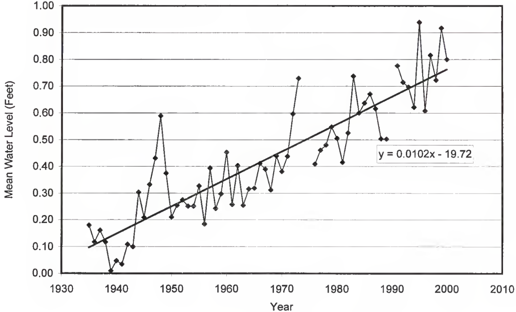


Figure 1-25. Yearly mean sea-level at the Ft. Pulaski, Georgia gage (Station No. 8670870) on the Savannah River. Data from NOAA, National Ocean Service 2002.

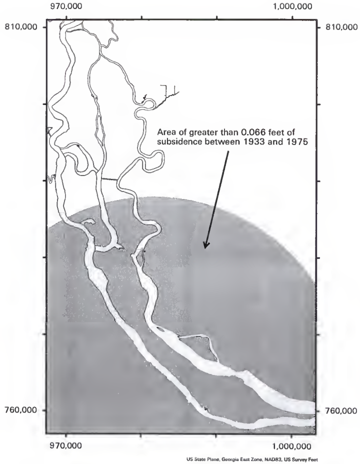


Figure 1-26. Land subsidence since 1933 resulting from municipal and industrial water withdrawals of groundwater in proximity to the study area (after Davis 1987).

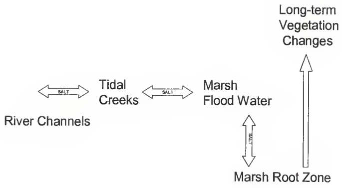


Figure 1-27. Linkages between river channel salinity and marsh root zone tracked by salinity monitoring protocol.

CHAPTER 2
METHODS

Mapping and Surveying

Aerial Photography Acquisition

Growing-season aerial photography was acquired during August 1999 by contract with a commercial aerial survey company (Aerial Cartographics of America, Inc., Orlando, Florida). Both true color and false-color infrared photographs were acquired at scales of 1:12,000 and 1:25,000; Figures 2-1 and 2-2, respectively, provide the flight lines and center locations for each scale. Photograph overlap along the flightlines is 80%.

To rectify the aerial photographs, targets were placed across the project area at ten locations specified by the contractor (Figure 2-3). Each target consisted of a white cross, 20-feet in width, made from 48-inch wide white plastic aerial flagging. Coordinates of each target center were determined using a differentially corrected GPS (Trimble Pro-XR GPS, Trimble Navigation, Inc., Sunnyvale, California). This model GPS receives a U.S. Coast Guard correction signal that is used to provide real time coordinates accurate to within 3.28 feet. The coordinate system used for the entire project was U.S. State Plane, Georgia East Zone, North American Datum (NAD) 1983 (with the 1990 correction), with units in U.S. Survey Feet.

Target coordinates were provided to the aerial survey contractor for subsequent preparation of rectified photography. The contractor supplied rectified images prepared by scanning 9- by 9-inch positive transparencies developed from the original 9- by 9-inch negative. Using the triangulated target coordinates, the scanned 1:25,000 scale infrared aerial photographs were rectified and digitally joined together to form a single photomosaic that covered the entire project area. The mosaic of the 1:25,000 aerial photographs was used as the reference image for rectification of selected 1:12,000 scale true color and infrared images.

River Channel and Tidal Creek Mapping

A detailed base map of river channels and tidal creeks (Figure 2-4) was prepared by on-screen digitizing from the rectified 1:12,000 and 1:25,000 scale aerial photographs. The digitizing was done in AutoCAD Map 2000, release 4 (AutoDesk 1999). This base-map was compiled into a shape file using ArcView 3.2 (Environmental Systems Research Institute, Inc., Redlands, California). For information on the use of ArcView and its terminology see *ArcView GIS Exercise Book, Second Edition* (Hohl and Mayo 1997).

Aerial Photograph Interpretation of the Tidal Creek Network

Photointerpretation and measurements of the existing tidal creek network were conducted using two sets of aerial photography of Argyle and Ursla Islands. One set was historical aerial photographs dated from 1952 that were obtained through the U.S. National Archives and Records Administration in College Park, Maryland. The other set was the 12,000 scale 1999 false-color infrared aerial photographs described above. Both sets of photographs were digitally scanned

by a commercial service (Aerial Cartographics of America, Inc., Orlando, Florida). The scanned photographs were rectified against the 1:25,000 scale base image using ERDAS Imagine. Tidal creek lengths as existing in 1952 were measured for comparison to the length of the same creeks as photographed in 1999. Length measurements were made using Imagine's measurement tools. The cumulative length, in linear feet, of each tidal creek system was measured as a comparative index of the extent of tidal creek development. These measurements included all channels and ditch remnants that comprised a particular tidal creek system.

Survey Instrumentation and Tidal Creek Cross-Sections

Cross-section elevations of tidal creeks were surveyed at 11 locations using a survey grade global positioning system (GPS) (Trimble Model 4800 RTK GPS, Trimble Navigation, Inc., Sunnyvale, California). This instrument provided vertical accuracy to 0.066 feet. All elevation data for the project were referenced to National Geodetic Vertical Datum (NGVD) 1929. Care was taken to ensure that the instrument was resting on the marsh sediment surface and not on raised areas such as root clumps or rhizomes. In addition, sediments of marsh interiors can be soft and depress under weight. Consequently, care was taken to not to disturb the marsh surface prior to obtaining an elevation reading.

Vegetation Studies

Field Surveys

To monitor vegetation, permanent belt transects were established at ten locations, labeled Q1 throughQ10, across the study area (Figure 2-5) in fall 1997. All belt transects were 2 feet in width. Nine belt transects were 500 feet in length

and one (Q3) was 600 feet in length. Q3 was extended an additional 100 feet to incorporate a *Spartina alterniflora* dominated area.

Transect locations were chosen to bracket the salinity gradient from freshwater to mesohaline, with an emphasis on the oligohaline-freshwater interface. Table 2-1 summarizes the general locations of the belt transects in relation to their associated river channels. River miles are measured from the mouth of the Savannah River. To highlight the position of each belt transect in relation to the salinity gradient, the transects are arranged from upriver to downriver.

Table 2-1. Locations of belt transects along their associated river channels.

	Savannah River Mile	Salinity Regime
Front River:		
Q1	23.5	freshwater
Q7	22.0	oligohaline
Middle River:		
Q9	24.0	freshwater
Q6	23.5	freshwater
Q5	22.5	oligohaline
Q10	21.5	oligohaline
Little Back River:		
Q8[a]	24.5	freshwater
Q4[b]	21.5	oligohaline
Q3[c]	20.5	oligohaline
Back River:		
Q2[d]	17.0	mesohaline

[a]Former Study Area 1 of Pearlstine et al. (1990) and Latham (1990)
[b]Former Study Area 2 of Pearlstine et al. (1990) and Latham (1990)
[c]Former Study Area 3 of Pearlstine et al. (1990) and Latham (1990)
[d]Former Study Area 4 of Pearlstine et al. (1990) and Latham (1990)

However, these four sampling locations are all located along the Little Back River and Back River. To include marshes associated with the Middle River and Front River, six additional belt transect locations were selected in fall 1997 based on a preliminary field reconnaissance of the Front River and Middle River, where a number of salinity measurements were obtained during high tide

using a hand held conductivity meter (YSI Model 30, Yellow Springs Instruments, Inc., Yellow Springs, Ohio). This preliminary work provided an estimate of the upriver extent of the salinity gradient, as it existed at that time on the two additional river channels, and the six additional belt transects were located to bracket the salinity gradient from freshwater upriver to brackish downriver.

For each belt transect, both ends and the intermittent 100-foot points were permanently marked with 10-foot long iron rebar stakes driven into the marsh sediments and, for visibility, covered with a stave of white PVC pipe. The x and y locations of all stakes marking the belt transects were determined by GPS.

Ground elevations along the entire length of each belt transect were also determined by GPS. Mean marsh surface elevations were calculated based on these belt transect elevation surveys.

Herbaceous vegetation was quantified along the entire length of the belt transect using a line-intercept method modified from Phillips (1959) and described in Wallace (1996) (Wallace, P. M., R. A. Garren, and D. R. Rich. 1996. Ecology of natural wetland communities in the Orange County eastern service area reclaimed water wetland system. Final report to the Orange County Public Utilities Division. Ecosystem Research Corporation, Gainesville, Florida. 358 pp.). Each belt transect was divided into contiguous 10-foot intervals along its length as illustrated in the top of Figure 2-6. Vegetative cover was assigned by species within each 10- by 2-foot cover interval using the scale given in Table 2-2. Cover is defined as "the area of ground within a belt transect which is occupied by the aboveground parts of each species when viewed from above" (Kent and Coker 1992). Although cover is usually estimated by visual observation

as a percent, total cover values can exceed 100% due to stratification or multiple layering of vegetation (Kent and Coker 1992).

Table 2-2. Cover value categories and percent cover ranges for each category.

Cover Category	Percent Cover Range
0	0
1	<1
2	1 –10
3	10 – 30
4	30 – 50
5	50 – 70
6	70 – 90
7	90 – 100

Species frequency was determined as presence or absence along each foot of the belt transect, so a maximum frequency of 10 was possible for each 10-foot interval. For example, if a given species was present in any three 1-foot segments of a given 10-foot interval, the frequency for that species for that interval would be 3.

Vegetation Analysis

Raw data for a belt transect were compiled in a rectangular data table with one row of data for each species found in the belt transect. Columns in the table corresponded to each of the 10-foot intervals along the belt transect and were further subdivided into sub columns in which the frequency and cover data for each species was entered. The data were summarized using the following statistical methods:

> ***Total Frequency*** = the total number of 1-foot segments in the entire belt transect where the species occurred. The maximum value is 500 for a 2 by 500-foot belt transect and 600 for the 2 by 600-foot belt transect.

Relative Frequency = the total number of 1-foot segments where the species occurred divided by the sum of the total frequencies of all species x 100.

Percent Cover = sum of cover assignment for each species within each 10-foot interval divided by the number of 10-foot intervals by 100.

Relative Cover = the percent cover of a species divided by the sum of percent cover of all species x 100.

Importance Value = the sum of relative frequency and relative cover. The maximum value possible is 200 for an individual species.

Frequency Rank = the numerical rank of the species within the plot based on the relative frequency of each species. A rank of 1 indicates the species occurred more frequently than any other.

Cover Rank = the numerical rank of the species within the plot based on the percent cover of each species. A rank of 1 indicates the plant covered more area than any other plant.

During the study, vegetation within the ten belt transects were sampled six times: October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001.

Concurrent with the collection of vegetative data, qualitative observations were recorded regarding the stability of marsh sediments. At some locations, sediments were well consolidated and easily supported weight. However, at other locations, sediments were unconsolidated and unable to support weight. The ability to walk in these areas depended on whether or not a vegetative root mat was present.

To facilitate interpretation of the data in relation to the numerous environmental gradients that exist, data analyses consisted of cluster analysis, detrended correspondence analysis (DCA), correlation analysis, and detrended canonical correspondence analysis (DCCA).

Cluster analysis was used to classify belt transects according to vegetation similarity and to detect change in floristic composition of the belt transects over time. The analysis was conducted using a commercial statistical ecology software package (Pisces Conservation, Ltd. 2000. Community analysis package, version 1.1. United Kingdom.). Some preliminary runs indicated that data analysis was more manageable if only those species with importance values greater than 10 were included. This reduced the number of species included in the analysis from 150 to 29. While rare species were eliminated, reducing the size of the data set made only small differences in the absolute similarity between each belt transect, and no difference in the final analysis. Cluster analysis is performed only on vegetation species data and does not include environmental data. However, the cluster results were interpreted with respect to general gradients that exist among belt transect locations.

DCA, an indirect ordination technique, was used as the first step in a process to quantify the underlying environmental gradients within the existing vegetation data and was conducted using the same software package as cluster analysis. As with cluster analysis, only floristic data were used in DCA and, in this case, consisted of importance values calculated from relative frequency and cover statistics. For the same reason as cluster analysis, only species with an importance value greater than 10 were included in the DCA. With DCA, a set of belt transect and species similarity scores were generated based on the floristic data. These data were then plotted on a set of axes in which the primary axis (x-axis) represents the strongest separation of plant data, presumably according to an underlying environmental gradient.

In contrast to the indirect approach of DCA, DCCA is referred to as a direct ordination technique since it directly regresses gradients in community species composition to environmental factors such as salinity or elevation. DCCA was conducted using a commercial statistical ecology software package (CANOCO 4, Microcomputer Power, Inc., Ithaca, New York).

Like DCA, DCCA calculates species scores and sample scores and calculates one or more ordination axes that explain the variation in the species data. The first axis explains the greatest percentage of the variance. The second axis explains the next greatest percentage of the variance while being uncorrelated with the first axis. Additional axes may be calculated as well.

Unlike DCA, in DCCA the ordination axes are constrained to be linear combinations of environmental variables (Kent and Ballard 1988). This allows the environmental factors to be regressed against the ordination axes. This is accomplished during the calculation of the species ordination axes by simultaneously calculating multiple linear regressions of the available environmental variables to find a combination that is most highly correlated with the ordination axes. The multiple linear regression of the environmental data that is most highly correlated with the first species axis is designated as the first environmental variable. Additional environmental variables are derived for the remaining species axes as necessary, with the constraint that the environmental axes are uncorrelated with one another.

The significance of the regressions derived by the DCCA is tested by a Monte-Carlo permututaion. When the p-value is less than 0.05 the relation

between the species axis and the environmental variable is significant at the 5% level.

Kent and Coker (1992) described the components of the DCCA diagram, also called a species-environment biplot. Superimposed on the plant community gradient ordination plot, an environmental variable is represented by an arrow pointing in the direction of maximum change of that variable. The more parallel the arrow is to either axis, the more highly correlated the environmental variable is to that axis. A longer arrow represents a greater magnitude of change and is therefore more important in influencing community variation.

The relationship of a species or a sample to the environmental variable can be determined by projecting a perpendicular line between the arrow and the plotted point representing the sample. Samples that have their perpendicularly projected points falling near or beyond the tip of the arrow are strongly correlated with the environmental variable. The farther away the projected points fall from the tip of the arrow, the less the samples represented by the points are influenced by the environmental variable. Arrows oriented orthogonal, or perpendicular, to one another are highly uncorrelated. The environmental variables represented by orthogonal arrows can therefore be highly influential in separating the samples along the first and second axes (CANOCO reference manual and user's guide: software for canonical community ordination, version 4. Microcomputer Power, Ithaca, New York. 352 pp.).

DCCA was used to compare belt transects to one another to determine environmental factors significant in affecting plant distributions from upriver to downriver locations. The environmental factors used in these analyses were

average salinity within the belt transect, average ground elevation of the belt transect, and the depth, frequency, and duration of tidal flooding. A second belt transect analysis was conducted using ranked data for salinity, where the belt transects were ranked from 1 to 10 based on average salinity, as well as ranked data for elevation.

DCCA was also used to compare species distributions within each belt transect. For these analyses, the data set reflected the species abundance and environmental factors at each 10-foot interval along the belt transect. Environmental factors comprising the data set were location (distance) of each 10-foot interval along the belt transect, elevation of the interval, average salinity within the 10-foot interval, and temporal standard deviation of the average salinity. Elevation data files used in the within belt transect DCCA were developed from the GPS surveys of each belt transect by extracting elevations at 10-foot intervals from cross-section drawings.

The salinity data files used in the within belt transect DCCA were developed from sediment salinity measurements taken along the belt transects during the six vegetation monitoring events. During each sampling event, salinity measurements were taken at 50 or 100-foot intervals along the belt transects. These data were averaged for the multiple sample times and linear interpolation was used to create data files with average salinity values at 10-foot intervals.

Correlation analysis is used to determine the "strength of relationships between variables" (Kent and Coker 1992, pg. 134). Correlation analysis attempts to relate the vegetation species variation with different environmental

variables, such as salinity and elevation. The degree of relationship between two variables lies between -1.0 through 0.0 to +1.0.

Two methods of correlation analysis were used to relate the data: Pearson's product-moment correlation coefficient (parametric) and Spearman's rank correlation coefficient (non-parametric). The significance of the correlation (r) using both methods is reflected in the results of a "t" test, which expresses how strongly the vegetation responds to the environmental data. "The significance test is designed to calculate the probability that for the given sample size, the correlation coefficient could have been derived by chance" (Kent and Coker 1992, pg. 137). The test is based on the use of "t" tables available in general statistics books (Steel and Torrie 1980). The measure of how much the variation in the vegetation data is explained by the environmental variables is determined by squaring the correlation coefficient (r^2).

Hydrologic and Salinity Data Collection

Salinity values were measured every 10 minutes at each of the ten vegetation belt transect locations as well as two additional locations, referred to as datalogging stations E and W (Figure 2-7). These two stations were located relatively near one another (approximately 1,200 feet) but were associated with two different tidal creek systems. Datalogging station E was associated with a tidal creek connected to a freshwater reach of the Little Back River. Consequently, freshwater was delivered to the marsh at datalogging station E during high tide. Conversely, datalogging station W received more saline waters via a tidal creek connected to the Middle River. In addition to salinity, water levels were measured in tidal creeks adjacent to each of the belt transects, as

well as datalogging stations E and W. Marsh surface elevations of datalogging stations E and W were determined using the GPS.

The monitoring stations and their associated sensors were placed to provide simultaneous monitoring of salinity in tidal creeks and in the adjacent marshes. The sensors monitored salinity within the tidal creeks, within the waters that flooded the marsh during high tide, and within the marsh sediments. Figure 2-8 provides a conceptual configuration of a typical monitoring station, depicted at both high tide and low tide. The marsh is flooded only during high tide. The specifics of water level and salinity monitoring instrumentation are discussed below.

Water Level Monitoring Instrumentation

Each monitoring station was configured around a 2-megabyte (MB) datalogger (Model CR10X, Campbell Scientific, Inc., Logan, Utah) housed in a weatherproof enclosure. Tide stages in tidal creeks were monitored using 10-foot lengths of Aquatape (Consilium US, Inc., Littleton, Massachusetts). This device consists of two thin, flexible metal ribbons attached along their edges to form a narrow double-sided tape. The electrical resistances of the tape changes as the two sides of the tape are pressed together by rising or falling tidal floodwater. The Aquatape was installed in a tidal creek within a stilling well constructed of 2-inch diameter PVC pipe, which provided both structural support for the Aquatape and protection from floating debris carried by the tide. The Aquatape resistance was calibrated to the water level by determining the water level elevation with the GPS.

The frequency, depth, and duration of tidal flooding were calculated from the automatically logged data. Frequency was calculated by counting the number of tide events whose stage exceeded the marsh elevation. Depth was determined by measuring the height of these tide events. Duration was determined by counting the number of data points (i.e., 10 minute intervals) collected when tide stage was above marsh elevation.

Salinity Monitoring Instrumentation

Concurrent with the installation of water level monitoring equipment, salinity-monitoring equipment was installed in both tidal creeks and marsh locations, corresponding to the 12-datalogging stations (Figure 2-9). Salinity was measured at each of the 12-datalogging stations and stored in one of two types of dataloggers. In tidal creeks, salinity was monitored using a YSI Model 6600 submersible datalogger equipped with a conductivity/temperature probe (Yellow Springs Instruments, Inc., Yellow Springs, Ohio). These instruments were suspended from buoys to maintain a constant depth below the water surface of approximately 1.64 feet. The datalogger was programmed to record conductivity, temperature, and salinity at 10-minute intervals. The recorded data were downloaded approximately every 30-days.

In marsh areas, salinity was measured with CSI Model 547 conductivity/ temperature probes (Campbell Scientific, Inc., Logan, Utah) wired to the same Campbell Scientific CR10X dataloggers to which the water level sensors were attached. Salinity probes were mounted within each marsh in two configurations. One probe was mounted to a fixed post and positioned approximately 0.066 feet above the marsh surface to monitor the high-tide floodwater salinity, and another

was installed just below the dense root mat, at the top of the unconsolidated sediments. To prevent plugging of the probe by fine clay, the latter probes were encased in a 1-foot long, gravel filled section of 4-inch PVC pipe capped on each end (Figure 2-9). The possibility that installation of the probe below the root mat would create an unnatural exchange pathway was of concern. To minimize this effect, the marsh root mat was neatly sliced with a sharp saw, carefully lifting the root mat and inserting the gravel packed sensor beneath it, and then replacing the root mat and leveling the area.

In addition to salinity data collected by the automatic dataloggers, additional field measurements of the sediment salinity within the plant root zones were collected concurrently with the vegetation monitoring. These salinity data were collected using a hand held salinity-conductivity-temperature meter (Model 30 SCT meter, Yellow Springs Instruments, Yellow Springs, Ohio). Readings were taken at 50-foot or 100-foot intervals along the belt transects by punching a 1-foot deep hole through the root mat with a 1.5-inch diameter piece of PVC well screen fitted with a sharp point. To prevent mixing of marsh surface water and the underlying interstitial water and to ensure integrity of the salinity measurement, field readings were only collected at low tide when there was no surface water on the marsh.

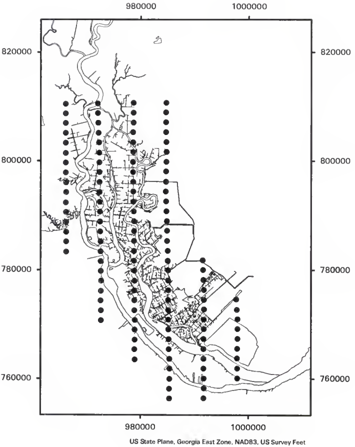


Figure 2-1. Flight lines and photograph center points for 1:12,000 scale true color and infrared aerial photography flown August 1999.

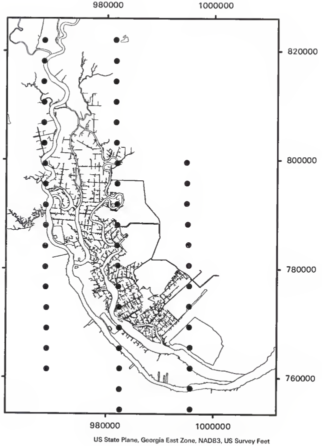


Figure 2-2. Flight lines and photograph center points for 1:25,000 scale true color and infrared aerial photography flown August 1999.

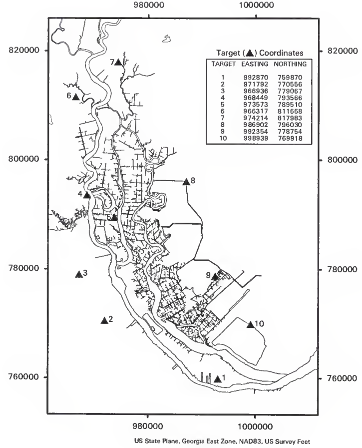


Figure 2-3. Locations and coordinates of aerial targets along the lower Savannah River used in rectification of August 1999 true color and infrared aerial photography.

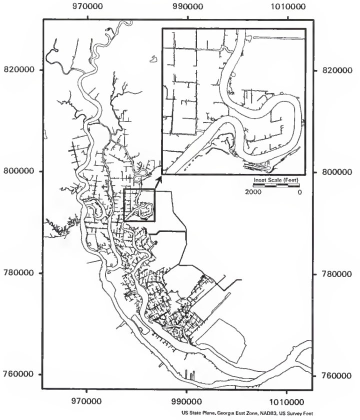


Figure 2-4. Base map of main river channels and tidal creeks digitized from rectified 1:12,000 and 1:25,000 scale aerial photography acquired August 1999. The detail to which the tidal creek system was digitized is highlighted in the inset.

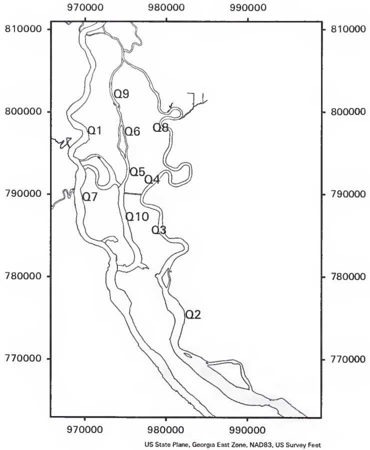


Figure 2-5. Permanent vegetation monitoring belt transect locations.

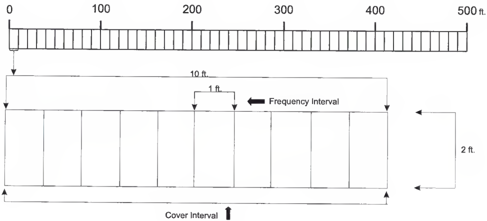


Figure 2-6. Typical 500-foot (ft.) vegetation sampling belt transect composed of 50 contiguous cover intervals. Enlargement of single cover interval details placement of 10 contiguous 1 by 2-foot frequency intervals within each cover interval. A total of 500 frequency intervals are present for each 500-foot quadrat.

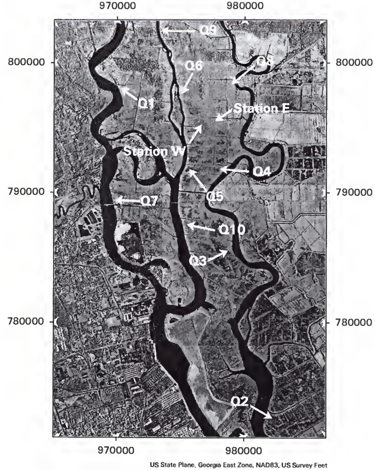
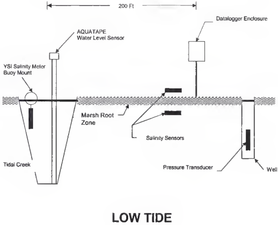


Figure 2-7. Locations of hydrologic and salinity datalogging stations.



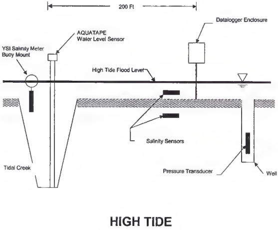


Figure 2-8. Hydrologic and salinity monitoring equipment setup at low tide and high tide.

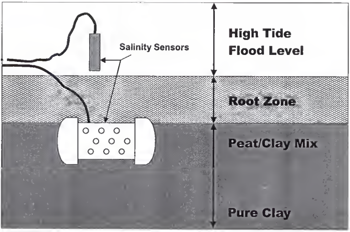


Figure 2-9. Positioning of salinity probes within marsh sediments and above marsh surface.

CHAPTER 3
RESULTS

Aerial Photograph Interpretation of the Tidal Creek Network

Table 3-1 provides lengths of the three main water supply canals (designated as the northern, central, and southern canals) that crossed central Argyle Island as measured from the 1999 aerial photograph (Figure 3-1). By 1999, only the remnants of these former canals remain. Table 3-1 provides the measured linear feet of the canal remnants and margin ditches shown in the 1999 aerial photograph.

Table 3-1. Tidal creek development on Argyle Island.

	Tidal Creek Network (linear feet)		
	Northern	Central	Southern
Canal length prior to sedimentation:	4,550	4,920	3,500
Current canal lengths:			
Middle River	1,730	730	1,110
Little Back River	2,560	3,890	2,100
Tidal creek development[a] from:			
Middle River	2,200	830	1,890
Little Back River	8,600	13,680	14,650

[a]Tidal creek development is expressed as the total linear feet of the canals and margin ditches that have become interconnected to form a discrete network of channels with a common point of connection to either the Middle River or the Little Back River.

While the systems originating from the Middle River have cumulative channel lengths ranging from 830 to 2,200 linear feet, the creek systems originating off the Little Back River range from 8,600 to 14,650 linear feet. One

aspect of this substantial difference is that the creeks originating from the Middle River have not formed the dendritic interconnections common in the Little Back River creek systems. The Middle River creek systems are straight-sectioned remnants of the former main water supply canals, with very little secondary interconnection with remnants of the former margin ditches.

As documented on the historical maps (Figures 1-13, 1-14, and 1-15) and compiled on Figure 3-1, several main water supply canals were constructed entirely across Argyle Island during the rice-growing era. These canals, fitted at each end with elaborate water control structures, conveyed water to the rice field squares via the wooden trunks. However, review of the 1999 aerial photograph (see Figure 1-18) indicates these canals have become blocked in the years since abandonment (Figure 3-2).

Interpretation of a 1938 aerial photograph of a portion of Argyle Island (Figure 3-3) indicates that open water surrounded by a vegetative fringe is visible in the interior of the former square. According to tide tables for the day the photograph was flown (26 October 1938), there was a spring high tide at 12:04 pm. Shadows cast by trees near the photograph center point (Figure 3-3) are east of due north, which indicate the sun was already westing when the photograph was taken. These shadows support the idea that the photograph was taken during midday, as opposed to mid-morning. Consequently, the tide stage depicted on the photograph is a high tide and indicates the presence of a pool of open water in the former rice field square.

The presence of a pool of open water within the former square in 1938 is in contrast to the completely vegetated former square found today (Figure 3-4).

Figure 3-4 is a portion of the infrared aerial photograph taken in 1999, showing the entire former square has become completely vegetated over the years since 1938. This former square, and typical of many of the former rice field squares that have reverted to tidal marsh, has an edge zone that is dominated by *Z. miliaceae*. Further, there is a very sharp demarcation between the *Z. miliaceae* dominated edges and the interior marsh, which is typically dominated by *Eleocharis fallax* and *Scirpus tabernaemontani*.

Marsh Surface Elevations

Cross-sections of the ten vegetation belt transects are shown in Figures 3-5 through 3-14. Table 3-2 provides marsh surface elevations at the mid-point of each 10-foot interval along the belt transect.

For comparison, surveyed cross-sections of former margin ditches and main water supply canals were superimposed on the historical cross-section in Figure 1-17. Comparison of the historical and present-day cross-sections indicates that the ground elevations of the marsh are substantially higher now than those of the former rice fields. The former profile of the embankments and margin ditches is no longer evident in the present day cross-sections; the embankments having eroded and the margin ditches filled in.

The surveyed cross-sections show that the ground surface elevation generally rises from the edge of the tidal creek to the marsh interior. This is in contrast to the common description of tidal creeks as having slightly elevated streamside levees (Mitsch and Gosselink 1993) resulting from differential sedimentation of coarser sediments as waters flood the marsh during high tide.

Table 3-2. Marsh surface elevations at 10-foot intervals along the ten vegetation belt transects.

Distance Along Belt transect (feet)	Marsh Surface Elevation (feet NGVD 1929)									
	Q1	Q2	Q3*	Q4	Q5	Q6	Q7	Q8	Q9	Q10
5	4.4	3.2	3.9	4.5	4.3	4.2	2.9	4.1	3.9	4.4
15	4.6	3.6	3.9	4.5	5.0	4.2	3.0	4.3	3.9	4.8
25	4.6	3.4	4.2	4.0	4.9	4.2	3.1	4.4	4.0	4.8
35	4.7	3.4	4.3	4.1	4.1	4.1	2.9	4.5	4.2	4.9
45	4.7	3.5	4.2	4.2	3.8	4.1	3.3	4.5	4.2	4.8
55	4.8	3.6	4.3	4.4	3.9	4.2	3.8	4.5	4.2	4.6
65	4.7	3.6	4.4	4.4	4.1	4.4	3.7	4.6	4.2	4.4
75	4.7	3.6	4.4	4.2	4.2	4.5	3.8	4.7	4.2	4.4
85	4.9	3.7	4.4	4.2	4.2	4.6	3.9	4.7	4.2	4.4
95	4.8	3.8	4.4	4.2	4.3	4.4	3.9	4.7	4.3	4.4
105	4.8	3.8	4.4	4.2	4.4	4.4	4.0	4.7	4.2	4.4
115	4.9	3.8	4.4	4.3	4.4	4.4	3.9	4.7	3.9	4.3
125	1.9	3.9	4.4	4.2	4.4	4.5	3.8	4.8	3.6	4.3
135	5.0	3.9	4.4	4.3	4.5	4.5	3.8	4.8	3.4	4.2
145	4.9	3.9	4.3	4.2	4.5	4.5	3.8	4.6	3.3	4.2
155	5.0	3.9	4.4	4.2	4.5	4.6	3.8	4.6	2.7	4.3
165	5.1	3.9	4.4	4.2	4.5	4.6	3.7	4.7	2.6	4.3
175	5.0	3.9	4.4	4.1	4.5	4.6	3.7	4.8	3.9	4.3
185	5.0	3.9	4.4	4.2	4.4	4.6	3.5	4.9	4.2	4.3
195	5.0	4.0	4.3	4.2	4.5	4.6	3.4	5.1	4.3	4.3
205	5.0	4.0	4.3	4.2	4.5	4.6	2.8	5.1	4.2	4.2
215	5.0	4.0	4.3	4.3	4.5	4.7	2.2	5.0	4.2	4.2
225	5.1	4.0	4.4	4.3	4.5	4.7	2.9	4.9	4.0	4.2
235	5.1	3.9	4.4	4.3	4.5	4.7	2.7	4.7	3.7	4.3
245	5.0	3.9	4.4	4.3	4.5	4.7	3.5	4.6	3.6	4.3
255	5.0	3.9	4.4	4.3	4.5	4.7	3 6	4.5	3.6	4.3
265	5.0	3.9	4.3	4.3	4.5	4.7	3.7	4.4	3.7	4.3
275	5.2	3.8	4.3	4.3	4.5	4.8	3.8	4.5	4.1	4.3
285	5.0	3.7	4.3	4.3	4.5	4.8	3.8	4.6	4.4	4.3
295	5.0	3.7	4.3	4.1	4.4	4.8	3.8	4.8	4.4	4.3
305	5.0	3.6	4.3	4.2	4.5	4.8	3.9	4.8	4.5	4.3
315	5.0	3.5	4.3	4.2	4.5	4.8	3.9	4.7	4.4	4.3
325	5.3	3.6	4.3	4.2	4.5	4.8	3.8	4.7	4.4	4.3
335	5.2	3.5	4.3	4.3	4.5	4.8	3.8	4.7	4.3	4.3
345	5.1	3.5	4.3	4.3	4.5	4.8	3.9	4.7	4.3	4.3
355	5.2	3.4	4.4	4.3	4.5	4.8	4.0	4.7	4.3	4.3
365	5.1	3.6	4.3	4.2	4.6	4.8	3.9	4.7	4.4	4.3

Table 3-2. Continued

Distance Along Belt transect (feet)	Marsh Surface Elevation (feet NGVD 1929)									
	Q1	Q2	Q3*	Q4	Q5	Q6	Q7	Q8	Q9	Q10
375	5.2	3.6	4.3	4.2	4.6	4.8	4.0	4.7	4.4	4.3
385	5.3	3.7	4.3	4.1	4.6	4.7	4.0	4.7	4.5	4.3
395	5.0	3.7	4.3	4.1	4.5	4.7	4.0	4.8	4.5	4.4
405	5.1	3.8	4.2	4.2	4.5	4.8	4.0	4.8	4.5	4.4
415	5.1	3.7	4.2	4.1	4.5	4.8	4.1	4.7	4.5	4.4
425	5.1	3.8	4.1	4.2	4.5	4.8	4.0	4.7	4.4	4.3
435	5.2	3.9	4.2	4.2	4.6	4.8	4.1	4.6	4.4	4.3
445	5.2	3.9	4.1	4.2	4.6	4.7	4.1	4.6	4.3	4.3
455	5.2	4.0	4.1	4.1	4.6	4.7	4.0	4.6	4.3	4.3
465	5.3	3.9	4.2	4.1	4.6	4.7	4.1	4.7	4.2	4.4
475	5.3	3.8	4.1	4.1	4.6	4.7	4.1	4.7	4.2	4.3
485	5.1	3.7	4.2	4.1	4.6	4.7	4.1	4.7	4.2	4.3
495	5.2	3.6	4.2	4.0	4.6	4.7	4.1	4.7	4.2	4.3
505	--	--	4.1	--	--	--	--	--	--	--
515	--	--	4.2	--	--	--	--	--	--	--
525	--	--	4.2	--	--	--	--	--	--	--
535	--	--	4.3	--	--	--	--	--	--	--
545	--	--	1.3	--	--	--	--	--	--	--
555	--	--	4.3	--	--	--	--	--	--	--
565	--	--	4.3	--	--	--	--	--	--	--
575	--	--	4.3	--	--	--	--	--	--	--
585	--	--	4.3	--	--	--	--	--	--	--
595	--	--	4.2	--	--	--	--	--	--	--
Average	4.9	3.7	4.2	4.2	4.5	4.6	3.7	4.7	4.1	4.4
Std. Dev	0.5	0.2	0.1	0.1	0.2	0.2	0.4	0.2	0.4	0.1

Q3 is 600 feet long; all other belt transects are 500 feet long.
NGVD = National Geodetic Vertical Datum, 1929

Vegetation Study Results

Results of the GPS survey of the ten permanent vegetation belt transect locations are provided in Table 3-3. This table documents the location of the belt transects including the x and y coordinates of the belt transect endpoints and the permanently staked 100-foot markers (i.e., the PVC poles).

Table 3-3. Coordinates and elevations at 100-foot points along vegetation belt transects.

Belt Transect	Distance[a] (feet)	Easting[b] (ft NAD83)	Northing[b] (ft NAD83)	Elevation[c] (ft NGVD29)
Q1	0	970319	797574	4.1
	100	970401	797631	4.8
	200	970483	797689	5.1
	300	970565	797746	5.1
	400	970647	797804	5.1
	500	970729	797861	5.2
Q2	0	982316	775313	3.7
	100	982400	775367	3.8
	200	982483	775423	4.0
	300	982562	775484	3.7
	400	982644	775541	3.7
	500	982728	775597	3.3
Q3[d]	0	979152	785351	3.8
	100	979052	785358	4.4
	200	978953	785366	4.3
	300	978853	785373	4.3
	400	978754	785379	4.2
	500	978653	785386	4.2
	600	978554	785393	4.3
Q4	0	978665	791963	4.3
	100	978564	791967	4.3
	200	978464	791971	4.2
	300	978365	791975	4.2
	400	978264	791978	4.1
	500	978164	791981	4.2
Q5	0	975249	791806	4.1
	100	975349	791808	4.3
	200	975448	791818	4.5
	300	975548	791828	4.4
	400	975647	791839	4.5
	500	975746	791849	4.6
Q6	0	974855	797412	4.3
	100	974952	797435	4.4
	200	975050	797460	4.6
	300	975147	797483	4.8
	400	975244	797508	4.7
	500	975341	797531	4.7

Table 3-3. Continued

	Distance[a] (feet)	Easting[b] (ft NAD83)	Northing[b] (ft NAD83)	Elevation[c] (ft NGVD29)
Q7	0	969657	789438	2.8
	100	969756	789448	3.9
	200	969856	789458	3.2
	300	969956	789467	3.9
	400	970055	789477	4.1
	500	970154	789486	4.1
Q8	0	979219	798279	4.0
	100	979120	798266	4.7
	200	979021	798252	5.2
	300	978922	798248	4.8
	400	978822	798234	4.8
	500	978724	798220	4.7
Q9	0	973305	802523	3.8
	100	973386	802581	4.3
	200	973473	802632	4.3
	300	973559	802683	4.5
	400	973644	802735	4.5
	500	973730	802785	4.2
Q10	0	975162	787460	4.1
	100	975260	787485	4.4
	200	975357	787510	4.2
	300	975454	787535	4.3
	400	975550	787560	4.4
	500	975647	787585	4.3

[a]Belt transect endpoints and 100-foot points are permanently marked with 10-foot iron stakes driven into marsh sediments and topped with white PVC pipe.

[b]Coordinates are U.S. State Plane, Georgia East Zone, North American Datum (NAD) 1983, U.S. Survey feet and determined by differentially corrected GPS.

[c]Elevation in feet relative to National Geodetic Vertical Datum (NGVD) 1929 and determined by real-time kinematic GPS survey accurate to 0.066 foot.

[d]Belt transect Q3 is 600 feet long. All others are 500 feet.

Results of the six vegetation sampling events are summarized in Table 3-4, which is a listing of all plant species found in the ten vegetation belt transects during the study period October 1997 through October 2001. A total of 150 plant species were identified in the ten belt transects.

Figures 3-15 through 3-24 provide percent cover and relative frequency of the top ten plant species for each of the ten belt transects for each of the six vegetation-sampling events.

Table 3-4. Listing of all plant species found in the ten permanent vegetation belt transects during the study period October 1997 through October 2001.

Species Code	Scientific Name	Common Name
ACE RUB	*Acer rubrum* L.	Red maple
AGA PUR	*Agalinis purpurea* (L.) Pennell	Gerardia
AGR PER	*Agrostis perennans* (Walter) Tuck.	Autumn bentgrass
ALN SER	*Alnus serrulata* (Aiton) Willd.	Hazel alder
ALT PHI	*Alternanthera philoxeroides* (Mart.) Griseb	Alligatorweed
AMA CAN	*Amaranthus cannabinus* (L.) J.D. Sauer	Tidalmarsh amaranth
AMP ARB	*Ampelopsis arborea* (L.) Koehne	Peppervine
AND GLO	*Andropogon glomeratus* (Walt.) BSP var. glomeratus	Bushy bluestem
API AME	*Apios americana* Medik.	Groundnut
ART HIS	*Arthraxon hispidus* (Thunb.) Makino	Small carpgrass
AST ELL	*Aster elliottii* Torr. & A. Gray	Elliott's aster
AST LAT	*Aster lateriflorus* (L.) Britton	Calico aster
AST NOV	*Aster novi-belgii* L.	New York aster
AST SUB	*Aster subulatus* Michx.	Annual saltmarsh aster
AST TEN	*Aster tenuifolius* L.	Perennial saltmarsh aster
BAC HAL	*Baccharis halimifolia* L.	Sea myrtle
BID LAE	*Bidens laevis* (L.) Britton et al.	Smooth beggarticks
BID MIT	*Bidens mitis* (Michx.) Sherff	Smallfruit beggarticks
BOE CYL	*Boehmeria cylindrica* (L.) Sw.	False nettle
BOL AST	*Boltonia asteroides* (L.) L'Her.	White doll's-daisy
CAL SEP	*Calystegia sepium* (L.) R. Br.	Hedge false bindweed
CAR ALA	*Carex alata* Torr.	Broadwing sedge
CAR COM	*Carex comosa* Boott	Longhair sedge
CAR LON	*Carex longii* Mack.	Long's sedge
CAR LUP	*Carex lupuliformis* Sartwell ex Dewey	False hop sedge
CAR SP1	*Carex* species 1	Sedge
CAR SP2	*Carex* species 2	Sedge
CEL LAE	*Celtis laevigata* Willd.	Hackberry
CEP OCC	*Cephalanthus occidentalis* L.	Common buttonbush
CHA FAS	*Chamaecrista fasciculata* (Michx.) Greene	Partridge-pea
CIC MAC	*Cicuta maculata* L.	Spotted water hemlock
CIN ARU	*Cinna arundinacea* L.	Wood reed
CLE CRI	*Clematis crispa* L.	Swamp leather-flower
COR FOE	*Cornus foemina* Mill.	Swamp dogwood

Table 3-4. Continued

Species Code	Scientific Name	Common Name
CYP HAS	*Cyperus haspan* L.	Haspan flatsedge
CYP LAN	*Cyperus lanceolatus* Poir.	Epiphytic flatsedge
CYP STE	*Cyperus stenolepis* Torr.	Flatsedge
CYP VIR	*Cyperus virens* Michx.	Green flatsedge
DUL ARU	*Dulichium arundinaceum* (L.) Britton	Threeway sedge
ECH CRU	*Echinochloa crusgalli* (L.) P. Beauv.	Barnyardgrass
ELE CEL	*Eleocharis cellulosa* Torr.	Gulf coast spikerush
ELE FAL	*Eleocharis fallax* Weath.	Creeping spikerush
ELE QUA	*Eleocharis quadrangulata* (Michx.) Roem. & Schult.	Squarestem spikerush
ELE VIV	*Eleocharis vivipara* Link	Viviparous spikerush
ERA ELL	*Eragrostis elliottii* S. Wats.	Elliott lovegrass
ERE HIE	*Erechtites hieracifolia* (L.) Raf.	Fireweed
ERY AQU	*Eryngium aquaticum* L.	Rattlesnakemaster
EUP LEP	*Eupatorium leptophyllum* DC.	Falsefennel
EUT CAR	*Euthamia caroliniana* (L.) Greene ex Porter & Britton	Slender goldenrod
FUI BRE	*Fuirena breviseta* (Cov.) Cov.	Umbrellagrass
GAL OBT	*Galium obtusum* Bigelow subsp. filifolium (Wiegand) Puff.	Bluntleaf bedstraw
HAB REP	*Habenaria repens* Nutt.	Waterspider false reinorchid
HAM VIR	*Hamamelis virginiana* L.	American witchhazel
HYD UMB	*Hydrocotyle umbellata* L.	Manyflower marshpennywort
HYP HYP	*Hypericum hypericoides* (L.) Crantz	St. Andrew's-cross
HYP MUT	*Hypericum mutilum* L.	Dwarf St.-John's-wort
HYP SP.	*Hypericum* sp.	St. John's-wort
ILE VER	*Ilex verticillata* (L.) A. Gray	Common winterberry
IRI VIR	*Iris virginica* L.	Virginia iris
JUN EFF	*Juncus effusus* L.	Soft rush
JUN ELL	*Juncus elliottii* Chapm.	Bog rush
JUN MAR	*Juncus marginatus* Rostk.	Grassleaf rush
JUN MEG	*Juncus megacephalus* M.A. Curtis	Big-head rush
JUN POL	*Juncus polycephalus* Michx.	Many-head rush
JUN SCI	*Juncus scirpoides* Lam.	Needle-pod rush
KOS VIR	*Kosteletzkya virginica* (L.) C. Presl. ex A. Gray	Virginia saltmarsh mallow
LEE SP.	*Leersia* sp.	Cutgrass
LIL CHI	*Lilaeopsis chinensis* (L.) Kuntze	Eastern grasswort
LOB CAR	*Lobelia cardinalis* L.	Cardinalflower
LOB GLA	*Lobelia glandulosa* A. Gray	Coastal plain lobelia
LON JAP	*Lonicera japonica* Thunb.	Japanese honeysuckle
LUD DEC	*Ludwigia decurrens* Walter	Wingleaf primrosewillow

Table 3-4. Continued

Species Code	Scientific Name	Common Name
LUD LEP	*Ludwigia leptocarpa* (Nutt.) H. Hara	Anglestem primrosewillow
LUD MIC	*Ludwigia microcarpa* Michx.	Small-fruit seedbox
LUD OCT	*Ludwigia octovalvis* (Jacq.) Raven	Mexican primrosewillow
LUD PAL	*Ludwigia palustris* (L.) Elliott	Marsh seedbox
LUD PIL	*Ludwigia pilosa* Walter	Hairy primrosewillow
LUZ FLU	*Luziola fluitans* (Michx.) Terrell & H. Rob.	Southern watergrass
LYC RUB	*Lycopus rubellus* Moench	Water hoarhound
MIK SCA	*Mikania scandens* (L. f.) Willd.	Climbing hempweed
MIM QUA	*Mimosa quadrivalvis* L.	Sensitive brier
MUR KEI	*Murdannia keisak* (Hassk.) Hand.-Mazz.	Marsh dewflower
MYR CER	*Myrica cerifera* L.	Wax myrtle
NYS AQU	*Nyssa aquatica* L.	Water tupelo
NYS BIF	*Nyssa sylvatica* Marsh. var. biflora (Walt.) Sarg.	Swamp blackgum
ONO SEN	*Onoclea sensibilis* L.	Sensitive fern
ORO AQU	*Orontium aquaticum* L.	Goldenclub
OSM REG	*Osmunda regalis* L.	Royal fern
OXY FIL	*Oxypolis filiformis* (Walt.) Britt.	Water dropwort
PAN DIC	*Panicum dichotomiflorum* Michx.	Fall panicum
PAN HEM	*Panicum hemitomon* Schult.	Maidencane
PAN RIG	*Panicum rigidulum* Nees	Redtop panicum
PAS URV	*Paspalum urvillei* Steud.	Vaseygrass
PEL VIR	*Peltandra virginica* (L.) Schott & Endl.	Green arrow arum
PER PAL	*Persea palustris* (Raf.) Sarg.	Swampbay
PHY AME	*Phytolacca americana* L.	American pokeweed
PLU ODO	*Pluchea odorata* (L.) Cass.	Saltmarsh fleabane
PLU ROS	*Pluchea rosea* Godfrey	Godfrey's marsh fleabane
POL ARI	*Polygonum* arifolium L.	Halberd-leaved tear-thumb
POL PUN	*Polygonum punctatum* Ell.	Dotted smartweed
POL SAG	*Polygonum sagittatum* L.	Tear-thumb
PON COR	*Pontederia cordata* L.	Pickerelweed
PTI CAP	*Ptilimnium capillaceum* (Michx.) Raf.	Mock bishop's-weed
PTI COS	*Ptilimnium costatum* (Ell.) Raf.	Bishop's-weed
QUE LAU	*Quercus laurifolia* Michx.	Swamp laurel oak
RHY COR	*Rhynchospora corniculata* (Lam.) A. Gray	Short-bristle beaksedge
RHY MCC	*Rhynchospora microcarpa* Baldwin ex A. Gray	Southern beaksedge
RHY MIC	*Rhynchospora microcephala* (Britton) Britton ex Small	Small bunched beaksedge
ROS PAL	*Rosa palustris* Marshall	Swamp rose
RUB ARG	*Rubus argutus* Link	Sawtooth blackberry

Table 3-4. Continued

Species Code	Scientific Name	Common Name
RUM VER	*Rumex verticillatus* L.	Swamp dock
SAC GIG	*Saccharum giganteum* (Walter) Pers.	Sugarcane plumegrass
SAC IND	*Sacciolepis indica* (L.) Chase	India cupscale
SAC STR	*Sacciolepis striata* (L.) Nash	American cupscale
SAG FIL	*Sagittaria filiformis* J.G. Sm.	Arrowhead
SAG GRA	*Sagittaria graminea* Michx.	Grassy arrowhead
SAG LAN	*Sagittaria lancifolia* L.	Bulltongue arrowhead
SAG LAT	*Sagittaria latifolia* Willd.	Common arrowhead
SAL CAR	*Salix caroliniana* Michx.	Carolina willow
SAM CAN	*Sambucus canadensis* L.	Elderberry
SAU CER	*Saururus cernuus* L.	Lizard's tail
SCI CYP	*Scirpus cyperinus* (L.) Kunth	Woolgrass
SCI PUN	*Scirpus pungens* Pers.	Threesquare bulrush
SCI ROB	*Scirpus robustus* Pursh	Saltmarsh bulrush
SCI TAB	*Scirpus tabernaemontani* C.C. Gmel.	Softstem bulrush
SES PUN	*Sesbania punicea* (Cav.) Benth.	Rattlebox
SIU SUA	*Sium suave* Walter	Hemlock waterparsnip
SOL SEM	*Solidago sempervirens* L.	Seaside goldenrod
SPA ALT	*Spartina alterniflora* (Loisel) var. glabra (Muhl. ex Elliott) Fernald	Saltmarsh cordgrass
SPA CYN	*Spartina cynosuroides* (L.) Roth	Big cordgrass
TAX DIS	*Taxodium distichum* (L.) Rich.	Bald cypress
TEU CAN	*Teucrium canadense* L.	Wood sage
TOX RAD	*Toxicodendron radicans* (L.) Kuntze	Poison ivy
TRI WAL	*Triadenum walteri* (J.F. Gmel.) Gleason	Greater marsh St.-John's-wort
TYP ANG	*Typha angustifolia* L.	Narrow-leaved cattail
TYP DOM	*Typha domingensis* Pers.	Southern cattail
UNK GRA	Unknown grass	---
UNK HER1	Unknown herb 1	---
UNK HER2	Unknown herb 2	---
UNK HER3	Unknown herb 3	---
UNK HER4	Unknown herb 4	---
UNK LEG1	Unknown legume 1	---
VIB DEN	*Viburnum dentatum* L.	Southern arrowwood
VIB NUD	*Viburnum nudum* L.	Possumhaw
VIG LUT	*Vigna luteola* (Jacq.) Benth.	Hairypod cowpea
VIO PRI	*Viola primulifolia* L.	Primroseleaf violet
WIS FRU	*Wisteria frutescens* (L.) Poir.	American wisteria
XYR IRI	*Xyris iridifolia* Chapm.	Irisleaf yelloweyed grass
ZIZ AQU	*Zizania aquatica* L.	Annual wild rice
ZIZ MIL	*Zizaniopsis miliacea* (Michx.) Doll & Asch.	Southern wild rice

The number of plant species found within each belt transect during each sampling event are summarized in Table 3-5.

Table 3-5. Number of plant species found within each belt transect during each vegetation sampling event.

Q	Oct-97	Oct-99	May-00	Oct-00	Jun-01	Oct-01	Average ± Std. Dev	Total[a]	Unique[b]
Q1	31	32	35	29	37	34	33 ± 3	50	1
Q2	7	6	7	6	6	6	6 ± 1	8	0
Q3	22	21	24	17	21	16	20 ± 3	31	1
Q4	18	13	24	10	30	18	19 ± 7	39	1
Q5	23	24	27	18	30	18	23 ± 5	40	0
Q6	41	29	43	34	36	36	37 ± 5	68	10
Q7	18	20	20	17	21	16	19 ± 2	25	0
Q8	56	57	60	66	63	77	63 ± 8	109	30
Q9	36	32	40	39	52	39	40 ± 7	67	11
Q10	18	16	17	13	14	12	15 ± 2	21	0

[a]Total species are all the different plant species within a belt transect that were identified at least once during the six sampling events.

[b]Unique species are those identified only at the indicated belt transect and were not found at any other location.

Cluster Analysis

The results of the belt transect cluster analysis are shown in Figure 3-25. This analysis included all ten belt transects over the six sampling events, for a total of 60 samples. The groupings of the belt transects indicate that, although changes in absolute similarity occurred between sampling events, each belt transect remained more floristically similar to itself than to the other belt transects.

The most pronounced deviation in this stability occurred within belt transect Q7, which in the two spring samplings (May 2000 and June 2001) clustered apart from the remainder of the data from this belt transect. This is primarily in response to the spring flush of green arrow arum (*Peltandra virginica* [L.] Schott & Endl.) that occurs at this belt transect. Therefore, these results

merely reflect inherent seasonal variation and not permanent change. While belt transect Q7 exhibited the most profound seasonal difference, other belt transect clusters also showed a spring-fall difference, although of lesser magnitude. The results of the cluster analysis also indicate that belt transect Q2 is very dissimilar to all other belt transects, which is expected since it is substantially more saline.

Detrended Correspondence Analysis (DCA)

The results of the DCA ordinations are shown in Figures 3-26 and 3-27. The basic output from DCA consists of simply labeled points plotted against two axes. For clarity, additional labeling and annotation have been added to the basic plots as described below.

Figure 3-26 provides the DCA results of the 60 belt transect samples. The figure includes two major axes, each of which represents an underlying gradient derived strictly from the vegetation data. DCA plots the x-axis as the major gradient detected by the analysis, with the y-axis representing the second strongest gradient. Each belt transect is plotted in relation to its floristic similarity to all other belt transects, with similar belt transects being plotted near one another, and dissimilar ones being plotted farther apart on the x and/or y axis.

The DCA separated the 60 belt transect samples into eight distinct groups, each circled on Figure 3-26 and labeled with the constituent belt transects. Samples from six of the belt transects (Q2, Q4, Q5, Q7, Q8, and Q9) formed discrete groups. However, belt transects Q3 and Q10 were mixed together as one group, as were belt transects Q1 and Q6. For reference, each group is labeled with the average salinity for the associated belt transect, and the number of plant species identified within each belt transect over the six sampling events.

While the x-axis represents the major axis derived from the floristic data by the DCA, it does not identify the gradient, and one must therefore be inferred (Kent and Coker 1992). Belt transects 2 and 8 are plotted at the extremes of the x-axis. These two transects represent the salinity extremes of the belt transects, with Q2 being the most saline and Q8 the most freshwater. These two belt transects share only one species in common, softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.), which, while common in Q2, is infrequent in Q8. These results support the hypothesis that the x-axis represents the salinity gradient.

The remaining six belt transects on Figure 3-26 are arranged along a general trend of increasing salinity from left to right across the plot, although as a group, all six are plotted in a somewhat central location and are separated from the extremes of the axis. Their centrist grouping is shifted slightly to the left of the axis, which is expected due to their lower salinity. The spatial distribution of belt transects in Figure 3-26 also shows a floristic relationship with the number of species found (i.e., the number of species decreases from 109 at belt transect Q8 to 8 species at Q2).

In spite of an overall trend toward increasing salinity by the central six groups in Figure 3-26, separation along the salinity gradient is not as clearly defined as the belt transect Q2 and Q8 groups. In fact, the three groups that contain Q1, Q4, Q6, and Q9 are not separated from each other along the x-axis. Separation among these groups is provided primarily by the secondary gradient represented along the y-axis. As with the x-axis, the identity of the y-axis is not determined by DCA and must be inferred.

Based on results of field observations recorded during collection of vegetation data within the belt transects, the degree of sediment consolidation was hypothesized as a potential gradient to at least partially explain the y-axis separation of the belt transect groupings on Figure 3-26. Belt transects Q1, Q5, Q6, and Q8 generally had more unconsolidated sediments than the other belt transects. Belt transects Q4, Q7, and Q9 are clearly separated along the y-axis from Q1, Q5, Q6, and Q8. However, belt transects Q3 and Q10, despite their consolidated sediments, are not differentiated along the y-axis from the four unconsolidated-sediment belt transects. This suggests that sediment consolidation is not an appropriate gradient or that additional factors, as yet undefined, contribute to the observed separation along the y-axis.

Figure 3-26 represents the results of a DCA based on belt transects, while Figure 3-27 provides these same belt transect results overlain with those of an additional DCA using the dominant species within each belt transect. This new ordination includes both species and belt transects to illustrate which vegetative species are responsible for the relationships of the belt transects to one another and why belt transect locations shift from one sampling to the next. Because belt transect locations on the ordination plot are determined by the weighted-mean averages of the species scores, the closer a species is plotted to the point representing a belt transect, the more dominant that species is within that belt transect. In general, three dominant species are responsible for the trends noted in the belt transects: softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.), southern wild rice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), and creeping

spikerush (*Eleocharis fallax* Weatherby). These species are noted in capital letters on the Figure 3-27.

With the exception of belt transect Q2, the general distribution of belt transects is determined by the three species indicated. Belt transects Q4 and Q9, which have a large population of southern wild rice (*Zizaniopsis milia*cea [Michx.] Doell & Aschers.), are located very close to this species on the plot. Belt transects Q3 and Q10 are dominated by softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.) and are situated spatially around this species. Belt transects Q8, Q1, Q6, and Q5 have large populations of creeping spikerush (*Eleocharis fallax* Weatherby); however, they are separated from this species on the graph because Q8, Q1, and Q6 have a large component of southern wild rice (*Zizaniopsis milia*cea [Michx.] Doell & Aschers.) and are therefore located spatially on the graph between these two species. Q5, in addition to having a substantial population of southern wild rice (Zizaniopsis miliacea [Michx.] Doell & Aschers.), is also codominated by softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.) and, therefore, the belt transect score is plotted to show the relative contribution of all three species.

The positions the belt transects are plotted on Figure 3-26 shift from one sample period to another. These shifts can be minor or relatively substantial. For example, the temporal floristic data for Q2 does not change significantly with season or sampling event; the belt transect scores are very tightly clustered and differ only in response to the small relative changes in vegetation occurring among sampling events. Even at Q8, the least saline of the belt transects, there was not a distinct trend associated with either seasonal or annual events. For

Q9, no temporal change in vegetation is apparent that is not explained by normal variation of the species population. Q4 showed a subtle, ill-defined, change with time with respect to axis 2; however, this corresponds to an increase in importance of creeping spikerush (*Eleocharis fallax* Weatherby) and a corresponding decrease in importance of southern wild rice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) at this transect. At both Q4 and Q9, no change with respect to a perceived salinity gradient (axis 1) is apparent.

In Q5, no seasonal trend was apparent; however, there was a temporal change that occurred with respect to both axes. The directional nature of this change is related to a decrease in the importance of southern wild rice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) and creeping spikerush (*Eleocharis fallax* Weatherby), with a corresponding increase in importance of perennial saltmarsh aster (*Aster tenuifolius* L.). The abundance of softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.) was essentially stable (Figure 3-27). This change, based on the perceived gradient defined by the x-axis, represents a response to increased salinities over the course of the study.

In Q1 and Q6, the 2001 samples seem to migrate in a positive direction on the x-axis and in a negative direction on the y-axis. This corresponds to a small increase in the importance of creeping spikerush (*Eleocharis fallax* Weatherby) and softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.) at both locations. However, the belt transect scores are so tightly clustered that these community changes are probably minimal.

Belt transects Q3 and Q10 are very similar floristically and are dominated by softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.). The sample scores

of both belt transects increased with respect to the x-axis and decreased with respect to the y-axis during the study period. The change in Q3 was due to the slight increase in importance of perennial saltmarsh aster (*Aster tenuifolius* L.) and substantial population expansion of three-square bulrush (*Scirpus pungens* Vahl.), while populations of softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.) and southern wild rice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) were stable. There is no apparent vegetative response to what would be attributed to elevated salinities at this belt transect.

The change in Q10 was more dramatic than that seen at Q3. Figure 3-27 shows a dramatic increase in the importance of perennial saltmarsh aster (*Aster tenuifolius* L.), with a corresponding decrease in the importance of southern wild rice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.). This response caused a shift along the primary axis and, coupled with salinity changes occurring across the belt transect during the study period, indicate that the plant community of the belt transect has become more saline.

Q7 displayed the most discernable temporal changes with apparent yearly and seasonal trends. The spring samples separate from the fall samples due to the spring flush of green arrow arum (*Peltandra virginica* [L.] Schott & Endl.) and New York aster (*Aster novi-belgii* L.). Annual drift in the belt transect scores is related to the decrease in the populations of smooth beggar-ticks (*Bidens laevis* [L.] BSP.) and southern wild rice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), with a corresponding increase in the salt tolerant species softstem bulrush (*Scirpus tabernaemontani* C. C. Gmel.), saltmarsh cordgrass (*Spartina alterniflora* Loiseleur), perennial saltmarsh aster (*Aster tenuifolius* L.), saltmarsh

bulrush (*Scirpus robustus* Pursh), and big cordgrass (*Spartina cynosuroides* [L.] Roth. Based on this analysis, coupled with the observed salinity changes at this belt transect, it is apparent that this belt transect has become more saline in floristic composition during the study period. This observation is supported by the prolonged drought conditions (Figure 1-8) and sediment salinity data collected within each belt transect during each of the vegetative sampling efforts.

Tide Stage and Water Level Studies Results

Table 3-6 provides a summary of the frequency, depth, and duration of tidal flooding at belt transects Q1 through Q10. Transects are ordered on the table according to their associated river, and from upriver to downriver. The average stage of the high tide at the ten belt transects ranged from a high of 4.8 feet at Q8 (River Mile 24.5), to a low of 4.4 feet at Q2, the most downriver monitoring location (River Mile 17.0). Flooding depth represents the difference between the average high tide stage and the average marsh elevation as derived from the surveyed cross-sections for each belt transect (Figures 3-5 through 3-14).

Figure 3-28 provides a series of box plots comparing the high tide ranges at each of the belt transects to the range of marsh surface elevations at each transect. As originally described by Tukey (1977), and illustrated in the legend in Figure 3-28, box plots are constructed around the data median. The upper and lower quartiles represent the median of data above and below the overall median, so that the area between the quartiles, or interquartile range (IQR), represents 50% of the data. The IQR allows an estimate of which of the remaining data points may be considered outliers by multiplying the IQR by 1.5 and adding or subtracting from the upper or lower quartile, respectively.

Table 3-6. Tidal flooding frequency, depth, and duration at the ten belt transects.

	Front River		Middle River				Little Back River & Back River			
Belt Transect	Q1	Q7	Q9	Q6	Q5	Q10	Q8	Q4	Q3	Q2
River Mile	23.5	22.0	24.0	23.5	22.5	21.5	24.5	21.5	20.5	17.0
Marsh Elevation (ft, NGVD 1929)										
Average	4.9	3.7	4.1	4.6	4.5	4.4	4.7	4.2	4.2	3.7
Std Dev	0.5	0.4	0.4	0.2	0.2	0.1	0.2	0.1	0.1	0.2
High Tides (ft, NGVD 1929)										
Average Stage	4.7	4.6	4.7	4.8	4.7	4.7	4.8	4.6	4.5	4.4
Std Dev	0.6	0.6	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.5
Minimum	2.7	2.7	3.3	2.7	2.8	2.8	3.4	2.6	2.3	3.1
Maximum	6.3	6.0	6.2	7.5	6.5	6.7	6.2	6.5	6.7	5.8
n	707	777	657	647	498	528	398	683	1130	196
Flooding Frequency										
Events above marsh elevation	247	731	547	384	304	365	222	500	732	177
Total high tides	707	777	657	647	498	528	398	683	1130	196
%	35	94	83	59	61	69	56	73	65	90
Flooding Depth (ft)	0.2	0.9	0.6	0.2	0.2	0.3	0.1	0.4	0.3	0.7
Flooding Duration (%)	9	37	28	15	31	25	17	23	32	29

ft = feet
NGVD = National Geodetic Vertical Datum, 1929

Data points falling outside the cutoff points may be potential outliers. The box plots also include the extreme upper and lower data value if they lie outside the outlier cutoff point.

In Figure 3-28, all data are referenced to vertical elevations. As these elevations are measured to an accuracy no greater than 0.1 foot, all values are rounded to 0.1 foot. In cases with a restricted data range, such as the marsh surface elevations at belt transects Q5, Q10, Q8, and Q4, rounding to the nearest 0.1 foot leads to situations where the median and either the upper or lower quartile are combined as the same value.

The results of the water level monitoring studies showed that the marsh at any particular location did not necessarily flood with every high tide. Results of the tide data analysis (Table 3-6) showed great within transect variability in the tide stage elevations, leading to variability in tidal flood frequency. This demonstrated variability is primarily due to the diurnal tide signature of the Savannah River, with two high tides of unequal height per day, as well as the differences resulting from the spring-neap cycle.

Table 3-6 provides the number of high-tide events recorded during the monitoring period at each belt transect. This number includes both the higher high and lower high tides. For example, at Q1, 707 high-tide events were recorded. Of these 707 events, only 247 (35%) were higher than the 4.9-foot mean marsh surface elevation. Consequently, Q1, which is located on the Front River at a very freshwater, upriver location, actually flooded fairly infrequently in relation to the twice-daily high tides. Conversely, Q2, the most downriver and

brackish belt transect, flooded very frequently. Of the 196 high tides recorded at Q2, 177 (90%) flooded the marsh.

Another belt transect that had frequent flooding was Q7, which flooded on 94% of the high tides. Q7 is located on the Front River (see Figure 2-5) and is the first open expanse of marsh upriver of the developed harbor at the Port of Savannah. The harbor has a deep, wide dredged channel that ends just downriver of Q7, providing a generous geometric cross-section for projecting tidal energy upriver. In addition, the banks of the river along the length of the harbor are lined with bulkheads and earthen berms, confining the tidal energy to the dredged channel until it is released onto the open marsh at Q7. Flooding depths for all belt transects are summarized on Table 3-6.

In addition to flooding frequency and depth, flood duration was derived from the continuous tidal record and expressed as a percentage of the total time the marsh was flooded over the entire duration of the data record (Table 3-6). High-tide flood duration within all belt transects averaged 25 $\pm$ 9%, ranging from a low of 9% at Q1 to a high of 37% at Q7.

Figures 3-29 and 3-30 provides a comparison between water levels within tidal creeks adjacent to Q1 and Q10, respectively and water levels simultaneously monitored within the adjacent marsh interiors. These comparisons demonstrate that water levels within the marsh interiors reached approximately the same depth as the adjacent tidal creeks; however, during the rising tide the peak water levels within the marsh interiors were always about 0.1 foot lower than the peak in the associated tidal creek. This difference represents

the hydraulic gradient necessary for water to flow from the tidal creek into the interior of the marsh.

At low tide even the lowest water levels in the marshes were substantially higher than many of the high-tide levels recorded within the tidal creeks, indicating the water tables in the marshes were perched relative to water levels in the adjacent tidal creeks. The exterior embankments of the former rice fields have eroded to form a perimeter of consolidated, low permeability sediments that holds water in the marsh even during low tide. Field observations confirmed that even during periods of low tide, when river water level may have been many feet below the elevation of the marsh surface, the marsh surface remained saturated with water. Therefore, the marsh interiors had a very restricted tide range in relation to the adjacent tidal creeks.

Ground elevation is the primary factor that contributed to the depth and duration of flooding at the marsh edges. Review of the vegetation belt transect cross-sections (Figures 3-5 through 3-14) indicate that the marsh margins adjacent to the tidal creeks tend to be slightly lower than the marsh interiors and, assuming a flat water surface, would have the potential to be flooded more deeply. Deeper flood depths may provide a partial explanation for the dominance of *Z. mili*aceae along the margins of the tidal creeks. When a rice field was abandoned, the exterior embankment began to erode as a result of relentless tidal action. Where these levees once projected above high-tide levels, they have been eroded to an equilibrium point with the high tide. Remnants of the embankments are now represented as a zone of firm, consolidated sediments adjacent to tidal creeks and main river channels.

Vegetation in the consolidated zones is dominated by tall, robust *Z. mili*aceae, which commonly grows in excess of 6 feet in height and has large rhizomes and stems (Godfrey and Wooten 1979). These structural features of the *Z. mili*aceae would be beneficial in stabilizing sediments and withstanding the tidal energy imposed by moving water and deep, prolonged flooding.

Salinity Study Results

Table 3-7 provides summary statistics on the average sediment salinity at each belt transect. The table is sorted from the most saline belt transect to the least saline. Average sediment salinities range from a high of 9.1‰ at Q2 to a low of 0.3 at datalogging station E.

Table 3-7. Summary statistics for sediment salinity data collected by the datalogging equipment within marsh sediments ranked by average salinity.

	No. of	Salinity (‰)				
Q	Observations[a]	Maximum	Median	Average	Std. Deviation	Minimum
Q2	16949	9.4	9.1	9.1	0.1	8.9
Q7	4345	10.6	8.1	8.0	1.0	6.3
Q10	3639	4.4	4.3	4.3	0.1	4.2
Q1	5611	3.2	3.0	2.9	0.4	2.2
Q5	21211	3.8	2.7	2.9	0.4	2.2
Q6	4523	2.6	2.0	2.1	0.2	1.9
Q9	4139	2.1	1.5	1.6	0.2	1.3
W	22819	5.6	1.4	1.6	0.5	0.7
Q3	22021	5.8	1.4	1.5	0.4	0.5
Q4	5548	1.4	1.3	1.3	0.1	1.1
Q8	22961	0.4	0.4	0.4	0.0	0.3
E	21488	0.6	0.3	0.3	0.1	0.2

[a]Continuous data collected at 10-minute intervals

The results of the field measurements of sediment salinities collected at 50- or 100-foot intervals along the vegetation belt transects during each of the vegetation sampling events are summarized in Figures 3-31 and 3-32. These

figures also show the steady rise in average salinity within each of the belt transects over the course of the study.

Figures 3-33 through 3-41 provide graphs of salinity for selected belt transects over selected time periods of monitoring. Salinity values within the tidal creeks were collected using sensors suspended from buoys that were free to move up and down with the tide, allowing continuous collection of data. Within the marsh and away from the tidal creeks, sensors mounted just above the marsh surface measured the salinity of the surface water covering the marsh during a high tide. The data collected by these sensors are discontinuous since they only measured salinity when the marshes were flooded, which, as discussed above, was intermittent. When marshes were not flooded, salinity sensors were suspended in air and returned salinity (or conductivity) readings of zero. Salinity sensors for the marsh surface waters were therefore either "on" or "off" depending on whether or not the marsh at a particular location was flooded to a depth that would cover the sensor. Consequently, when graphed, salinity data for the marsh surface waters are depicted as a series of discrete, discontinuous "spikes". The height of a spike reflects the salinity of the marsh floodwater during that high-tide event. The width of the base of the salinity spike reflects the duration when the sensor was covered with floodwater during the high-tide event.

Figure 3-33 provides an example of the salinity sensor response during times of flooding and no flooding at belt transect Q1. On Figure 3-33, marsh surface water salinity and pore water salinity are included in the top half of the figure, while tide stage in the adjacent tidal creek is shown on the bottom half. The marsh surface elevation at the location of the salinity sensor is

approximately 5.0 feet. Between day 305 and 315, the high tide water level in the creek only rose high enough twice, between days 309 and 311, to flood the marsh to a depth sufficient to cover the surface water salinity sensor. These two floodings of the marsh surface are noted on the salinity graph as spikes between days 309 and 311. Between days 317 and 322, the marsh floods on almost every tide, producing additional salinity spikes.

Results of the continuous salinity monitoring of the marsh sediment water indicate that salinities are generally stable. However, under some circumstances, sediment salinity may increase rapidly (i.e., on a single tidal cycle). Sediment salinity may then oscillate during additional tidal cycles. For example, at datalogging station W, starting on approximately day 200 (Figure 3-41), salinity increases from approximately 1.8 to 2.5‰ over two successive tidal cycles. On the next high tide on day 202, sediment salinity increases from 2.5 to over 4.5‰. Over the next several days, sediment salinity oscillates in response to the relative salinity of the high-tide floodwater. If the floodwater has lower salinity, sediment salinity decreases. If the floodwater has a higher salinity than the sediment salinity, sediment salinity increases.

The same sudden salinity increase experienced at datalogging station W around day 200, with a subsequent decrease to pre-increase salinity levels, is also indicated in data from other belt transects. Q3 (Figure 3-36), Q8 (Figure 3-38), and datalogging station E (Figure 3-40) all show the phenomenon to some degree. However, sediment salinity at Q2 (Figure 3-34) seems to be fairly stable at around 9‰.

When comparing sediment salinity to floodwater salinity at Q3 (Figure 3-36), Q8 (Figure 3-38), datalogging station E (Figure 3-40), and datalogging station W (Figure 3-41), the latter was well in excess of the sediment salinity around day 200, and the subsequent increase in the sediment salinity does not seem surprising. However, there are other instances on these same data records (review events around day 128 and day 140) that show floodwater salinities well in excess of the sediment salinity, but with no accompanying change in the sediment salinity.

The response of the sediment salinity in relation to floodwater salinity is at least partially explained by concurrently considering the tidal flooding regime (Figures 3-33 through 3-41). Figures 3-35 and 3-36 (Q3), Figure 3-38 (Q8), Figure 3-40 (datalogging station E), and Figure 3-41 (datalogging station W) provide comparisons of salinity changes and tidal regimes. Typical diurnal tide at these locations floods the marsh only during the higher high-tide event, with the lower high tide not being of sufficient height to flood the marsh. However, on day 200 and the next several days, both the higher and lower high tides flood the marsh. Consequently, the marsh is suddenly being flooded more often, and in this instance, with water of higher salinity. In addition, at Q8 (Figure 3-38), note how the marsh surface salinity readings are "extended" and do not exhibit the more typical "spike" signature. This indicates that the marsh was flooded for an extended period, not draining during low tide. The marsh stage recorder also shows extended flooding during this time, with the lower high tide being higher than the ground surface. Typically, only the higher high tide is above the marsh surface and has the potential to flood the marsh.

Although the salinity monitoring data at Q2 did not capture the day 200 event, it is doubtful that the sediment salinity at Q2 would have shown the same response to the twice daily flooding as shown at Q3, Q8, and datalogging stations E and W. Results of the water level monitoring at Q2 demonstrated that this belt transect routinely floods on both the higher and lower high tide, so sediment salinity is already at maximum exposure and consequently remains fairly stable. Therefore, the twice-daily flooding phenomenon would be of no consequence.

Integration of Vegetation Data with Environmental Parameters

Correlation Analysis

Correlation analysis results relating plant species within each of the vegetation belt transects with the environmental parameters of sediment salinity, flooding depth at high tide, and belt transect elevation are provided in Tables 3-8, 3-9, and 3-10, respectively. These tables present results of both Pearson's and Spearman's correlation analyses using both percent frequency of plant species within each belt transect, as well as percent cover.

For each of the environmental parameters, the ten highest Pearson's and Spearman's correlations (either positive or negative) and their associated species are listed, along with the standard deviations. The results of the correlation analyses further support the hypothesis that the primary axes of the DCA plots represent the salinity gradient.

Pearson's correlation coefficients for *T. angustifolia, S. alterniflora*, and *S. robustus* are all highly correlated with salinity (Table 3-8), with correlation coefficients of 0.98, 0.97, and 0.93, respectively. These species are associated

Table 3-8. Pearson's and Spearman's correlation coefficients for species versus average sediment salinity and temporal standard deviation of salinity.

Average Salinity				Temporal Standard Deviation of Salinity			
Species	Percent Cover Pearson's Correlation	Species	Percent Cover Spearman's Correlation	Species	Percent Cover Pearson's Correlation	Species	Percent Cover Spearman's Correlation
TYP ANG	0.98	PON COR	-0.94	TYP ANG	0.98	TYP ANG	0.92
SPA ALT	0.97	PTI CAP	-0.93	SPA ALT	0.96	PON COR	-0.88
SCI ROB	0.93	AST TEN	0.90	SCI ROB	0.95	PTI CAP	-0.75
PON COR	-0.65	SPA ALT	0.84	PON COR	-0.65	ERY AQU	-0.68
SPA CYN	0.57	CYP HAS	-0.83	SPA CYN	0.63	JUN POL	-0.68
ZIZ MIL	-0.53	TYP ANG	0.82	PTI CAP	-0.45	JUN ELL	-0.67
AST ELL	-0.46	ZIZ MIL	-0.78	ZIZ MIL	-0.45	AST TEN	0.66
POL PUN	-0.45	SCI TAB	0.76	POL PUN	-0.43	SCI ROB	0.65
PTI CAP	-0.44	SCI ROB	0.76	AST ELL	-0.39	CYP HAS	-0.65
MIK SCA	-0.41	GAL OBT	-0.74	ELE CEL	-0.39	SPA ALT	0.64
Species	Frequency Percent Pearson's Correlation	Species	Frequency Percent Spearman's Correlation	Species	Frequency Percent Pearson's Correlation	Species	Frequency Percent Spearman's Correlation
TYP ANG	0.98	AST TEN	0.90	TYP ANG	0.97	TYP ANG	0.91
SPA ALT	0.94	PTI CAP	-0.87	SCI ROB	0.93	ELE CEL	-0.81
SCI ROB	0.91	AST ELL	-0.81	SPA ALT	0.92	PON COR	-0.74
ZIZ MIL	-0.76	PON COR	-0.80	SPA CYN	0.78	JUN ELL	-0.73
SPA CYN	0.74	CYP HAS	-0.80	ZIZ MIL	-0.70	ERY AQU	-0.68
PON COR	-0.68	SPA ALT	0.80	PON COR	-0.64	JUN POL	-0.68
AST ELL	-0.52	ZIZ MIL	-0.79	ELE CEL	-0.49	AST TEN	0.66
POL PUN	-0.52	TYP ANG	0.79	POL PUN	-0.48	PTI CAP	-0.66
AST TEN	0.52	GAL OBT	-0.78	AST ELL	-0.43	SCI ROB	0.63
ELE CEL	-0.45	ELE QUA	-0.72	AST TEN	0.41	LUD PAL	-0.63

Table 3-9. Pearson's and Spearman's correlation coefficients for species versus average depth of flooding during high tide and temporal standard deviation of depth.

Average Depth				Temporal Standard Deviation of Depth			
Species	Percent Cover Pearson's Correlation	Species	Percent Cover Spearman's Correlation	Species	Percent Cover Pearson's Correlation	Species	Percent Cover Spearman's Correlation
ELE FAL	-0.93	ELE FAL	-0.88	ELE FAL	-0.82	PEL VIR	0.81
CAR COM	-0.79	CYP HAS	-0.84	SCI TAB	0.77	ELE FAL	-0.78
LEE SP.	-0.79	LEE SP.	-0.84	OXY FIL	0.72	LEE SP.	-0.78
XYR IRI	-0.76	ZIZ AQU	-0.83	SCI PUN	0.72	GAL OBT	-0.78
ZIZ AQU	-0.73	SCI ROB	0.83	LEE SP.	-0.71	HYD UMB	-0.78
CYP STE	-0.73	CAR COM	-0.79	ELE QUA	-0.70	CAR COM	-0.78
ELE QUA	-0.72	CAR ALA	-0.75	CAR COM	-0.69	CYP HAS	-0.77
LYC RUB	-0.71	CAR LON	-0.75	PLU ROS	0.66	AGA PUR	-0.76
AGA PUR	-0.69	XYR IRI	-0.75	XYR IRI	-0.64	SCI TAB	0.76
CAR ALA	-0.69	AGA PUR	-0 72	HYD UMB	-0.64	LYC RUB	-0.76
		GAL OBT	-0.72				
		HYD UMB	-0.72				
Species	Frequency Percent Pearson's Correlation	Species	Frequency Percent Spearman's Correlation	Species	Frequency Percent Pearson's Correlation	Species	Frequency Percent Spearman's Correlation
ELE FAL	-0.90	CYP HAS	-0.86	ELE FAL	-0.81	CYP HAS	-0.85
LEE SP.	-0.79	SCI ROB	0.86	OXY FIL	0.72	PEL VIR	0.81
CAR COM	-0.79	ZIZ AQU	-0.83	SCI PUN	0.72	MUR KEI	-0.81
ZIZ AQU	-0.76	LEE SP.	-0.82	PLU ROS	0.69	ELE FAL	-0.78
XYR IRI	-0.75	ELE FAL	-0.81	CAR COM	-0.69	LEE SP.	-0.76
LYC RUB	-0.70	MUR KEI	-0.79	LEE SP.	-0.68	AGA PUR	-0.76
CAR ALA	-0.70	CAR COM	-0.75	ELE QUA	-0.66	SCI TAB	0.76
CYP STE	-0.70	XYR IRI	-0.75	XYR IRI	-0.63	LYC RUB	-0.76
LUD PIL	-0.69	CAR LON	-0.75	LUD PIL	-0.63	HYD UMB	-0.75
AGA PUR	-0.67	CAR ALA	-0.75	HYD UMB	-0.63	CAR LON	-0.75
						CAR COM	-0.75
						CAR ALA	-0.75
						XYR IRI	-0.75

Table 3-10. Pearson's and Spearman's correlation coefficients for species versus average belt transect elevation and temporal standard deviation of belt transect elevation.

Average Belt Transect Elevation				Spatial Standard Deviation of Belt transect Elevation			
Species	Percent Cover Pearson's Correlation	Species	Percent Cover Spearman's Correlation	Species	Percent Cover Pearson's Correlation	Species	Percent Cover Spearman's Correlation
ELE FAL	0.87	ELE FAL	0.95	CYP VIR	0.71	CYP VIR	0.65
SPA CYN	-0.83	CAR COM	0.80	NYS BIF	0.69	CIC MAC	0.65
LEE SP.	0.69	CAR LON	0.76	TYP DOM	0.64	HYD UMB	0.63
CAR COM	0.68	XYR IRI	0.76	SES PUN	0.63	SCI TAB	-0.58
ZIZ AQU	0.68	CAR ALA	0.76	LUD DEC	0.63	NYS BIF	0.53
ELE QUA	0.66	CYP STE	0.75	LUD LEP	0.61	CAL SEP	0.52
SCI ROB	-0.63	ZIZ AQU	0.74	ELE QUA	0.60	LYC RUB	0.51
XYR IRI	0.62	SPA CYN	-0.74	SCI TAB	-0.58	LUD PIL	0.51
LUD LEP	0.62	LEE SP.	0.73	HYD UMB	0.55	LEE SP.	0.50
CYP STE	0.59	CYP HAS	0.71	LEE SP.	0.50	POL ARI	0.49
Species	Frequency Percent Pearson's Correlation	Species	Frequency Percent Spearman's Correlation	Species	Frequency Percent Pearson's Correlation	Species	Frequency Percent Spearman's Correlation
ELE FAL	0.87	ELE FAL	0.90	CYP VIR	0.71	SCI TAB	-0.72
SPA CYN	-0.82	CAR LON	0.76	NYS BIF	0.69	CYP VIR	0.65
ZIZ AQU	0.72	CAR ALA	0.76	TYP DOM	0.64	CIC MAC	0.65
SCI ROB	-0.71	CAR COM	0.76	LUD DEC	0.63	HYD UMB	0.57
CAR COM	0.67	XYR IRI	0.76	ELE QUA	0.62	NYS BIF	0.53
LEE SP.	0.66	ZIZ AQU	0.74	SES PUN	0.62	LYC RUB	0.51
XYR IRI	0.61	CYP HAS	0.74	LUD LEP	0.61	LUD PIL	0.51
ELE QUA	0.61	SPA CYN	-0.74	HYD UMB	0.52	POL ARI	0.49
LUD LEP	0.61	MUR KEI	0.74	AST ELL	0.50	LUD DEC	0.47
JUN ELL	0.59	LEE SP.	0.71	BOL AST	0.49	LUD LEP	0.47

with Q2 as depicted on the DCA plot in Figure 3-27. *T. angustifolia* also has the highest correlation coefficients with any of the four permutations of the salinity standard deviation (Table 3-8), indicating that *T. angustifolia* thrives in areas of fluctuating salinity.

Detrended Canonical Correspondence Analysis (DCCA)

DCCA results correlating belt transects with salinity and the hydrology related factors of marsh surface elevation, flooding frequency, depth, and duration are provided in Figure 3-42. Review of the DCCA ordination plot reveals that the hydrologic parameters of flooding frequency, depth, and duration are inversely, but highly correlated with marsh surface elevation. The marsh surface elevation arrow (Figure 3-42) is slightly longer than the other hydrologic parameter arrows, indicating a stronger correlation with the ordination axes than the shorter arrows. DCCA results correlating belt transects with ranked salinity and ranked elevation are provided in Figure 3-43. This plot shows a strong correlation of salinity rank with the x-axis, and the arrows point towards Q2 and Q10, which are the most downriver and saline belt transect locations.

DCCA was also run on the average species frequency of the individual belt transects. Table 3-11 provides a summary of all the DCCA correlations between each of the belt transects and the environmental variables. The highest correlations for the distance variable were found associated with the first axis at belt transects Q1 (-0.83), Q2 (-0.83), Q3 (0.97), Q7 (-0.86), and Q9 (0.87). Distance was never highly correlated with the second species axis for any of the belt transects. The highest correlations for the distance variable were 0.85 for the first axis of Q10 and –0.77 for the first axis at Q7. The highest correlation for

Table 3-11. Summary of the DCCA correlations of the first two species axes with the environmental variables.

Belt Transect:	Q1		Q2		Q3		Q4		Q5		Q6		Q7		Q8		Q9		Q10	
Environmental Variable	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2
Distance	-0.83	0.002	-0.83	0.14	0.97	-0.04	-0.71	-0.15	-0.73	0.24	-0.87	-0.33	-0.86	-0.35	-0.71	0.24	0.87	-0.09	-0.65	0.60
Elevation	-0.38	-0.16	-0.30	-0.60	-0.23	0.18	0.54	-0.51	0.28	-0.01	-0.51	-0.47	-0.34	-0.77	-0.66	-0.51	0.45	-0.19	0.85	-0.07
Average Salinity	0.48	0.34	0.66	-0.23	-0.71	0.49	-0.52	-0.04	-0.56	-0.48	0.17	0.49	0.92	0.006	-	-	-0.50	-0.28	0.04	-0.71
Std. Deviation Salinity	0.04	0.06	0.35	0.13	-0.75	-0.04	0.63	0.33	-0.67	0.06	0.002	0.48	0.92	-0.03	0.10	-0.20	-0.59	-0.64	-0.71	0.18
eigenvalue	0.32	0.04	0.14	0.02	0.40	0.13	0.30	0.09	0.65	0.05	0.28	0.09	0.35	0.22	0.26	0.11	0.43	0.19	0.60	0.16
% Variance Species Data	19.9	22.5	29.0	34.0	17.0	22.3	16.3	21.4	28.0	30.2	8.3	10.9	19.3	31.2	8.1	11.7	9.9	14.2	36.9	46.5
% Variance Species/Enviro Data	61.8	69.7	68.0	79.7	53.3	70.2	58.1	76.2	65.1	70.2	46.4	60.9	46.9	76.2	42.3	60.8	46.5	66.6	67.7	85.2
p	0.005	-	0.005	-	0.005	-	0.005	-	0.005	-	0.005	-	0.005	-	0.005	-	0.005	-	0.005	-

average salinity was the first species axis at Q7. The standard deviation of average salinity was most highly correlated with the first axis of Q7 (0.92), followed by the first axis of Q3 (-0.75). Of all the belt transects, only Q7 had a high correlation with all of the environmental variables used in the analysis.

Figure 3-44 shows the DCCA biplots for each individual belt transect. The labels for the individual sample points are automatically placed by the DCCA software and often overlap, resulting in a certain lack of clarity. The biplots are arranged in order of increasing average salinity, with belt transect Q8 being the least saline and Q2 the most. Each point on an individual plot represents the sample scores for the 50 (or 60 in the case of Q3) individual 10-foot intervals that comprise the belt transect.

Using the plot for Q1 in Figure 3-44 as an example, the arrows representing the environmental axes are longest for distance and average salinity. The arrow representing distance is parallel to the first species axis, representing a very strong correlation with the species gradient. Average salinity and elevation are negatively correlated with one another. The standard deviation of the average salinity does not represent a strong environmental factor. The sample scores on the DCCA plot for belt transect Q1 are labeled 1 through 50 and are loosely aggregated into 3 groups. Each group is generally comprised of points labeled with sequential numbers, which indicates that each of the groups is mostly comprised of adjacent 10-foot intervals along the belt transect. The grouping of intervals 1 through 16 in the DCCA plot for belt transect Q1 reflects more stable, consolidated sediments. The remaining length of the belt transect had unstable, unconsolidated sediments.

The DCCA plot in Figure 3-44 can be compared to Figure 3-15, the plot of the cover values for the top ten species found within belt transect Q1. The most dispersed group of sample scores in the DCCA plot represents the first 16 10-foot intervals (i.e., the first 160 feet) of belt transect Q1, and is dominated by *Z. miliaceae*, especially in the first 100 feet. After a brief expression of dominance by *Leersia* sp. from 120 feet through approximately 200 feet, *Eleocharis fallax* becomes the dominant species for the remainder of the belt transect. The sediment composition along belt transect Q1 was noted to be consolidated for approximately the first 150 feet of its length and unconsolidated thereafter.

The effects of salinity are most evident within belt transect Q2, where the species richness is limited to eight species. In the DCCA plot for Q2 (Figure 3-44), the relatively long lengths of the arrows representing the environmental variables of distance, elevation, and average salinity indicate all three variables contribute a substantial influence on the community structure. The shorter length of the standard-deviation-of-salinity arrow indicates proportionally less influence than the other variables. The arrows for distance and average salinity are nearly diametrically opposed, indicating that a high negative correlation between the two variables, with the effects of average salinity being most pronounced near the beginning of the belt transect. Both variables are nearly parallel to, and highly correlated with, the first axis, indicating a strong contribution by average salinity and distance in separating samples along the first species axis. When the 50 sample points included in the biplot for Q2 are projected onto the distance arrow (the arrows representing the variables may be extended backwards through the central origin), they are generally arranged in order from interval 1 through 50,

with the higher numbered intervals being located more toward the tip of the arrow, indicating that community structure is more influenced by position along the transect as the distance from the river edge increases. Adjacent to the river edge, however, average salinity becomes more important, as indicated by the projection of the sample points onto the arrow representing the average salinity. The lower numbered intervals are located near the tip of the average-salinity arrow, with the higher numbered samples located along the tail of the arrow behind the plot center point.

Both the distance and average-salinity arrows within the Q2 biplot are orthogonal to the elevation arrow, indicating a lack of correlation between elevation and the other two variables. However, elevation is highly correlated with the second axis and accounts for the species spread along the second axis.

The influence of the environmental variables on community structure is reflected graphically in the vegetation cover value plot for belt transect Q2 (Figure 3-16). The first 100 to 150 feet of the transect, depending on the sample date, is heavily dominated by *Typha angustifolia*, which reached 100% cover within a number of the sample intervals. The relatively lower cover of *Typha angustifolia* within the first 50 feet of the transect is due to an increasing presence of *Spartina alterniflora* along the river edge over the course of the six sampling events. Increasing encroachment of *Spartina alterniflora* at the beginning of the transect may reflect the increasing salinity of the sediment salinities over the course of the study. The location of the *Spartina alterniflora* near the river edge may also reflect the higher salinity within the river channels resulting from the drought.

Elevation within Q2 varies between 3.2 and 4.0 feet (Figure 3-6) with the low points occurring within the initial 100 feet, in a shallow depression between 300 and 400 feet along the belt transect, and within the final 40 feet. Projection of the sample points onto the elevation arrow within the biplot results in a majority of the samples being located near the centroid, indicating a lack of either positive or negative influence on the part of elevation. Sample points near the beginning of the transect and bracketing the 350-foot point are plotted along the tail of the elevation arrow, behind the centroid, and indicate a negative correlation. The sample points that project nearest the tip of the elevation arrow are from intervals 44 through 48, located 440 through 480 feet along the transect. The projection of sample points 49 and 50 places them near the centroid. Despite similarities in elevation between the beginning of the transect and the area between 300 and 400 feet, there do not seem to be any community similarities that would explain why samples from these areas are projected onto the same region of the elevation arrow. The plant species near the edge may be indicating the edge is well drained, while different plant species situated at the same elevation but more interior may reflect a lack of drainage and more standing surface water.

In contrast to the strong influence of average salinity in defining the community structure of the most saline belt transect, Q2, average salinity had no influence on community structure within the most freshwater belt transect, Q8. The average salinity for all the intervals comprising Q8 was 0.4‰. While these values were included in the environmental data input to the DCCA, the CANOCO software excluded them from the analysis. While the standard deviation of salinity was used in the analysis, the length of the arrow representing this

variable on the biplot indicates that it was not an influential parameter. Within Q8, distance and elevation are the most influential variables in determining community structure. They are roughly orthogonal to one another, however, neither is approximately parallel to either the first or second axis. When the sample points are projected onto the distance arrow, two distinct groupings emerge. The first group consists of the sample points representing the intervals 1 through 10, or the initial 100 feet of the transect. These ten sample points project onto the distance arrow behind the centroid, indicating that distance along the transect has little influence on community structure adjacent to river edge. The first 100 feet of the transect is dominated by *Zizaniopsis miliaceae* (Figure 3-22). The elevation of the first 50 to 60 feet of the transect is slightly lower than the remainder of the transect (Figure 3-12). The second distinct grouping of the sample points along the Q8 distance arrow forms a dense cloud of points clustered around the centroid and extending toward the tip of the arrow. The points are generally arranged in sequential order with the 50th interval occurring nearest the tip. When the Q8 sample points are projected onto the elevation arrow, they occur in a broad distribution on both sides of the centroid. Points from the beginning of the transect, intervals 1 through 6, and points from intervals 25 through 28 are projected onto the distal end of the elevation arrow, indicating a negative correlation. Both of these segments within the belt transect have lower elevations. The portion of the transect between intervals 25 through 28 is dominated by a dense stand of the shrub *Alnus serrulata*. As *Alnus serrulata* spreads outward it shades the underlying vegetation and causes the root mat to disintegrate, leaving a soup of treacherously unconsolidated sediments.

However, both the highest point and nearly the lowest point along the transect occur within the clump of *Alnus serrulata* that dominates between the 180- and 290-foot points.

At belt transect Q10, the elevations within the first 100 feet of the transect (Figure 3-14) are higher than the remainder of the transect, which is flat. The higher elevation is the remnant of the dike surrounding the former rice field. The difference in elevation at the beginning of the belt transect Q10 is reflected in the DCCA plot. The arrow for the elevation variable is nearly parallel to the first axis, indicating a strong influence by elevation on community structure. When the sample points for Q10 are projected onto the elevation arrow, the points representing the first 100 feet of the transect extend from the centroid nearly to the tip of the arrow, indicating a strong influence of elevation on the community structure of the initial 100 feet of the transect. After 100 feet the remainder of the transect is flat and the community structure is not differentiated by elevation, as shown by the amorphous concentration of points projected onto the elevation arrow just behind the centroid. Vegetation within the first 100 feet of Q10 includes *Alternanthera philoxeroides*, *Scirpus robustus*, and *Spartina alterniflora*, none of which occur at any other point along the transect. Over the course of the study *the Scirpus robustus* and *Spartina alterniflora* have increased in cover within the first 100 feet of Q10 (Figure 3-24).

At belt transect Q7, the arrows representing average salinity and the standard deviation of salinity are highly correlated with the first axis (Figure 3-44). Sample points projected onto these lines show a strong influence of the salinity parameters on the first 160 feet of the transect, where sediment salinity values

were generally higher than the remainder of the transect (Figure 3-31). The salinity gradient along the transect may help explain the influence of the distance component, although it is less highly correlated with the first axis than the salinity parameters. Elevation is reasonably correlated with the second axis and, based on the long length of its representative arrow, exerts a strong influence on community structure. For example, the sample points nearest the tail of the arrow represent intervals 21 through 24 of the belt transect and are associated with a drainage rivulet in the marsh surface located between 200 and 240 feet along the transect (Figure 3-11). The transect cross-section shown in Figure 3-11 has an exaggerated vertical scale so the rivulet appears much more dramatic in graphic profile than it does in the field, where it is sparsely vegetated by a monoculture of *Zizaniopsis milia*ceae (Figure 3-21). Because the portion of Q7 located between 200 and 240 feet has the lowest elevations within the transect, the associated sample points are negatively correlated with the elevation component in the DCCA plot. The first 50 feet of Q7 also has relatively low elevations, when compared to the majority of the transect, and the associated sample points are also negatively correlated with elevation. However, sample points 1 through 5 are positively associated with salinity and are plotted toward the tip of the salinity parameter arrows. Positively associated with the elevation component are those portions of the transect bracketing approximately the 100-foot point, and located between 400 and 500 feet. These portions of the transect have the highest elevations.

For all belt transects, the species composition was highly correlated with distance along the belt transect. Correlations were both negatively and positively

correlated and ranged from –0.67 at Q6 to 0.97 at Q3. In all instances $p < .005$, which is likely due to the large number of samples (i.e., 50 or 60) within each belt transect. Salinity within each belt transect was not a significant factor in affecting species distributions along the transect. This is expected because the salinity did not vary substantially within an individual transect. Salinity differences on the order demonstrated between belt transects is necessary to affect species differences.

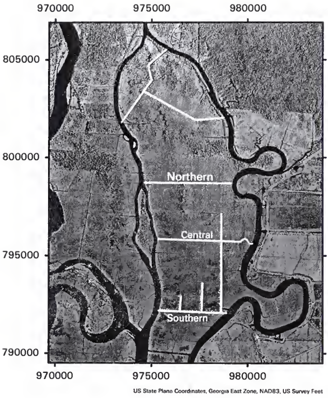


Figure 3-1. Infrared aerial photograph (1999) with locations of rice-era main water supply canals on Argyle Island.

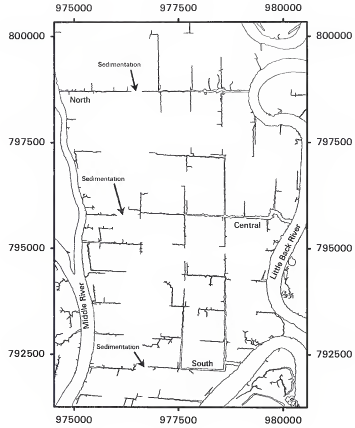
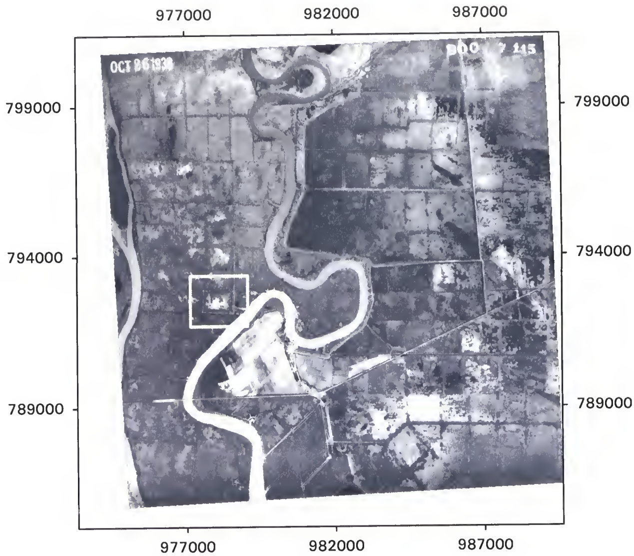


Figure 3-2. Dendritic development of tidal creek networks on Argyle Island associated with the Middle River and the Little Back River. Areas of sedimentation in the former main canals are noted.



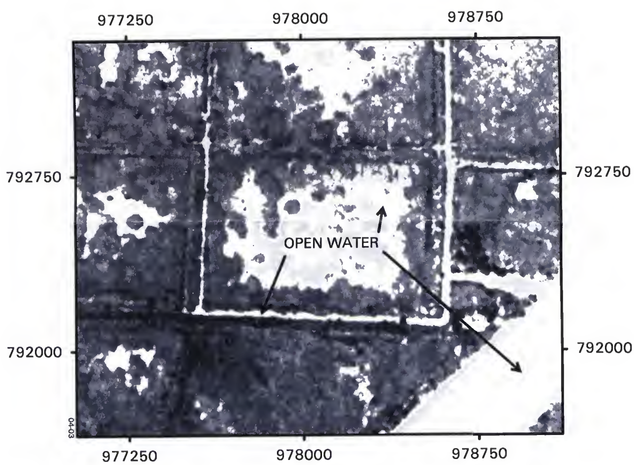


Figure 3-3. Aerial photograph (1938) of a portion of Argyle Island and the Little Back River and an unsupervised classification showing a pool of open water. The top photograph highlights a former rice field square that is the subject of the unsupervised classification in the bottom photograph. The photograph shows the presence of the presence of a pool open water within the square during a high tide.

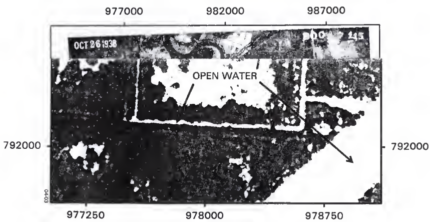


Figure 3-3. Aerial photograph (1938) of a portion of Argyle Island and the Little Back River and an unsupervised classification showing a pool of open water. The top photograph highlights a former rice field square that is the subject of the unsupervised classification in the bottom photograph. The photograph shows the presence of the presence of a pool open water within the square during a high tide.

Figure 3-4. False color infrared aerial photograph (1999) of a former rice field square located on Argyle Island.

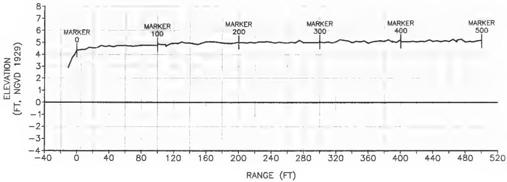


Figure 3-5. Belt transect Q1 surveyed cross-section.

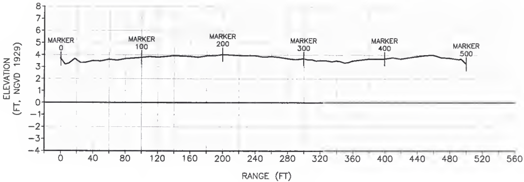


Figure 3-6. Belt transect Q2 surveyed cross-section.

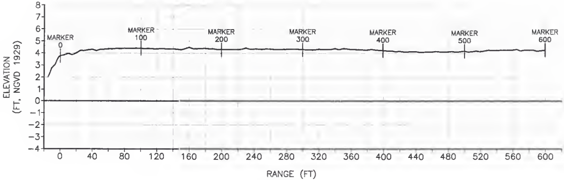


Figure 3-7. Belt transect Q3 surveyed cross-section.

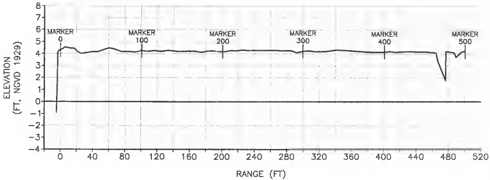


Figure 3-8. Belt transect Q4 surveyed cross-section.

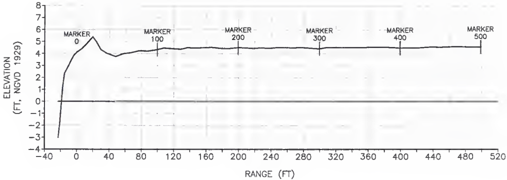


Figure 3-9. Belt transect Q5 surveyed cross-section.

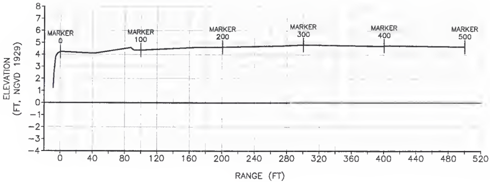


Figure 3-10. Belt transect Q6 surveyed cross-section.

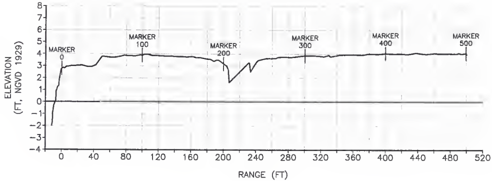


Figure 3-11. Belt transect Q7 surveyed cross-section.

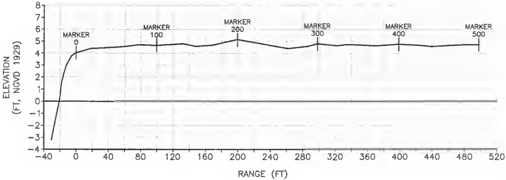


Figure 3-12. Belt transect Q8 surveyed cross-section.

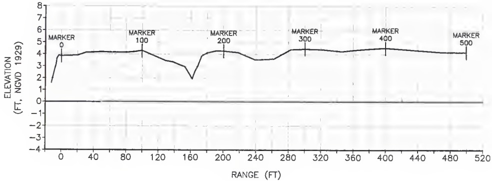


Figure 3-13. Belt transect Q9 surveyed cross-section.

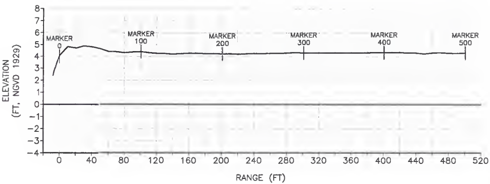


Figure 3-14. Belt transect Q10 surveyed cross-section.

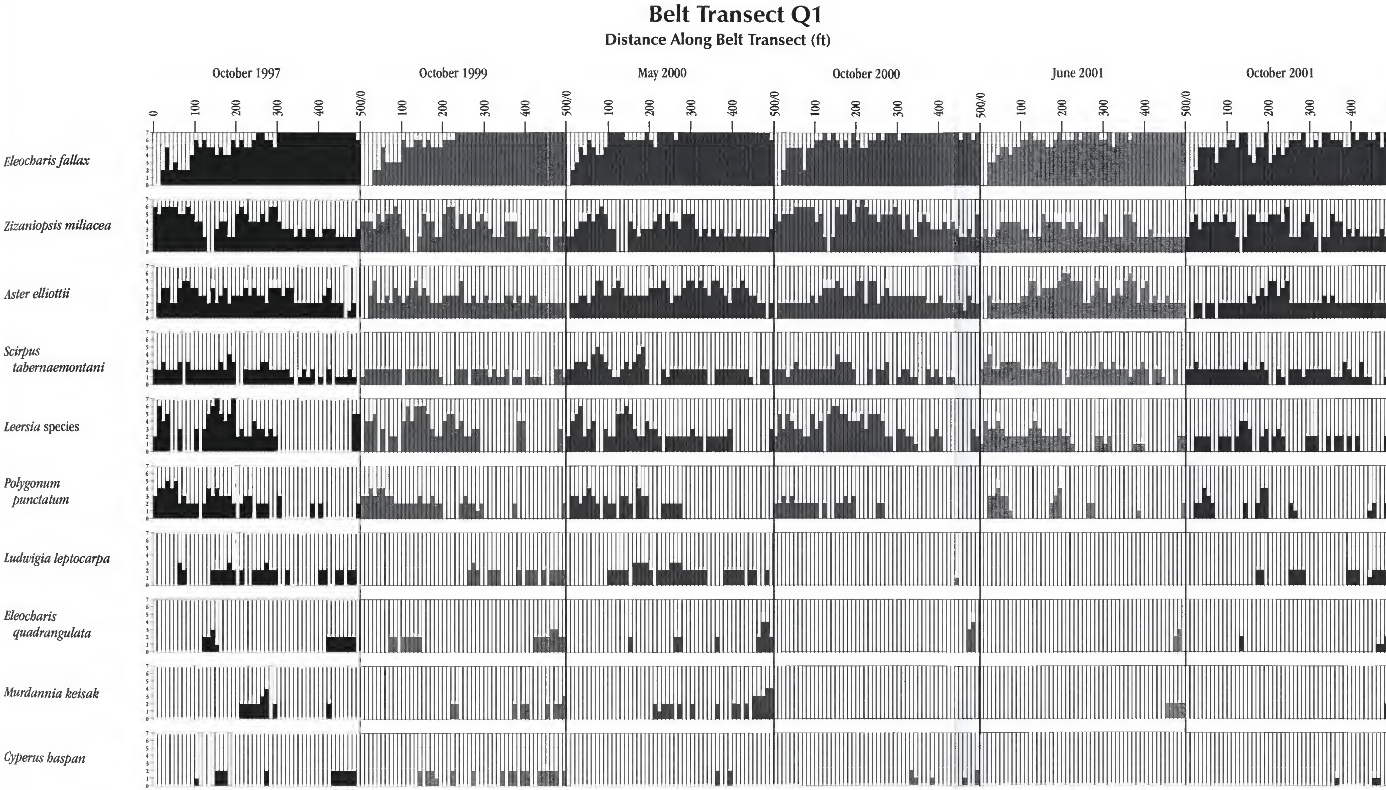


Figure 3-15. Belt transect Q1 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

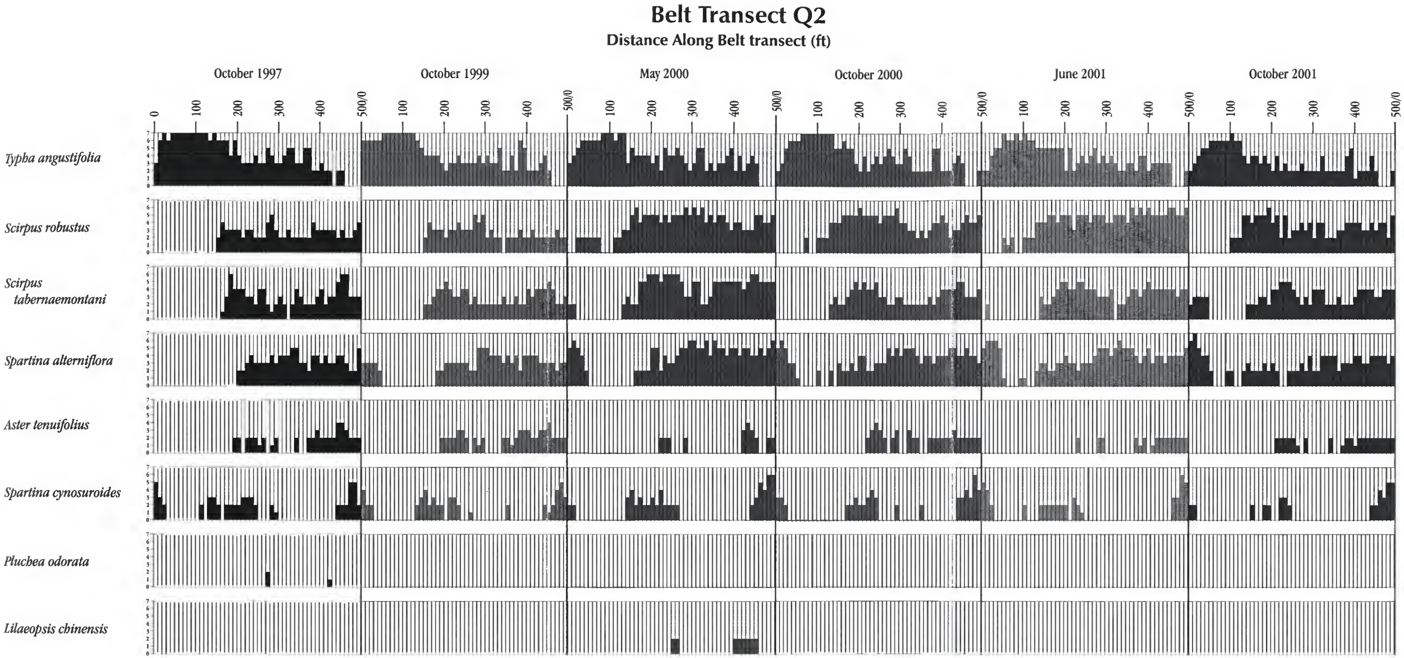


Figure 3-16. Belt transect Q2 cover values of all plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

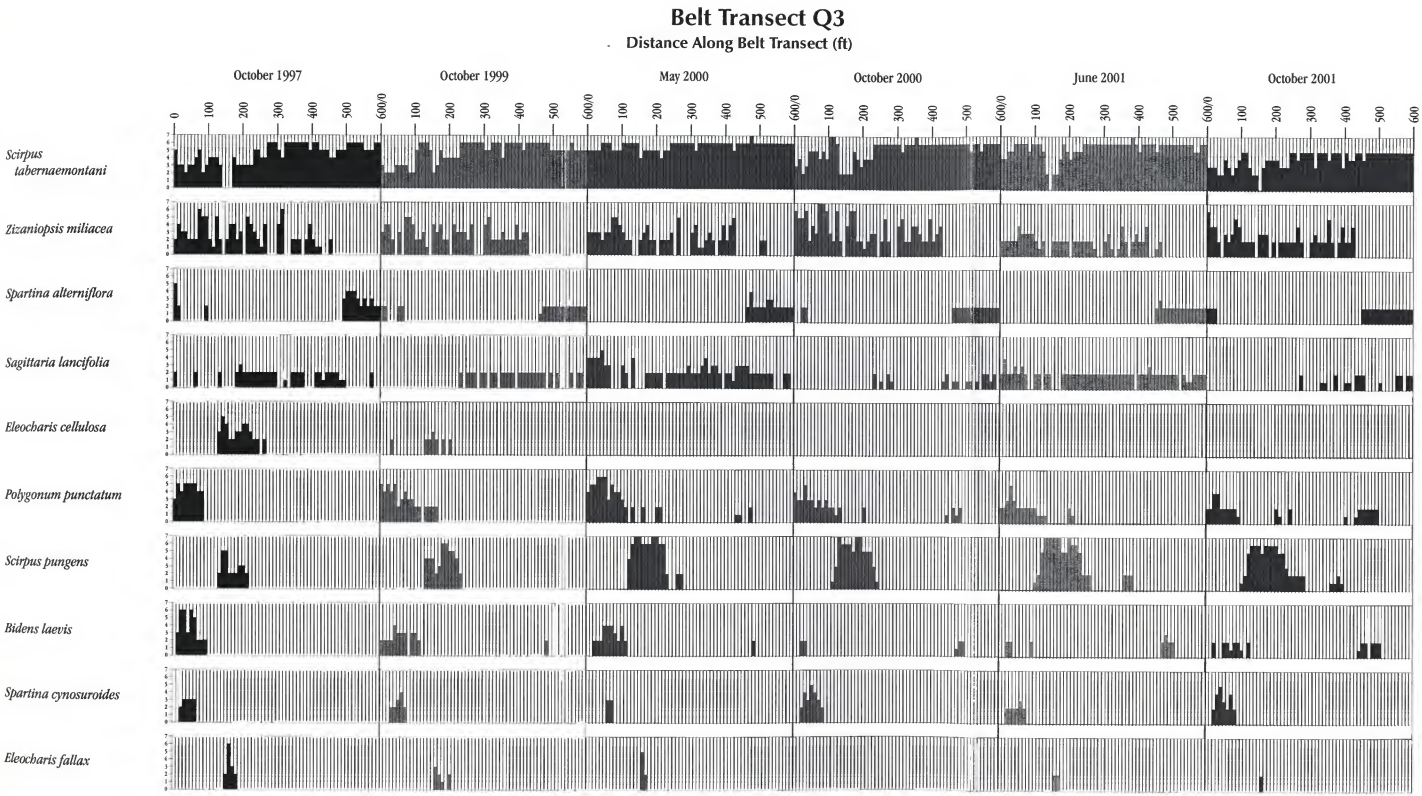


Figure 3-17. Belt transect Q3 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

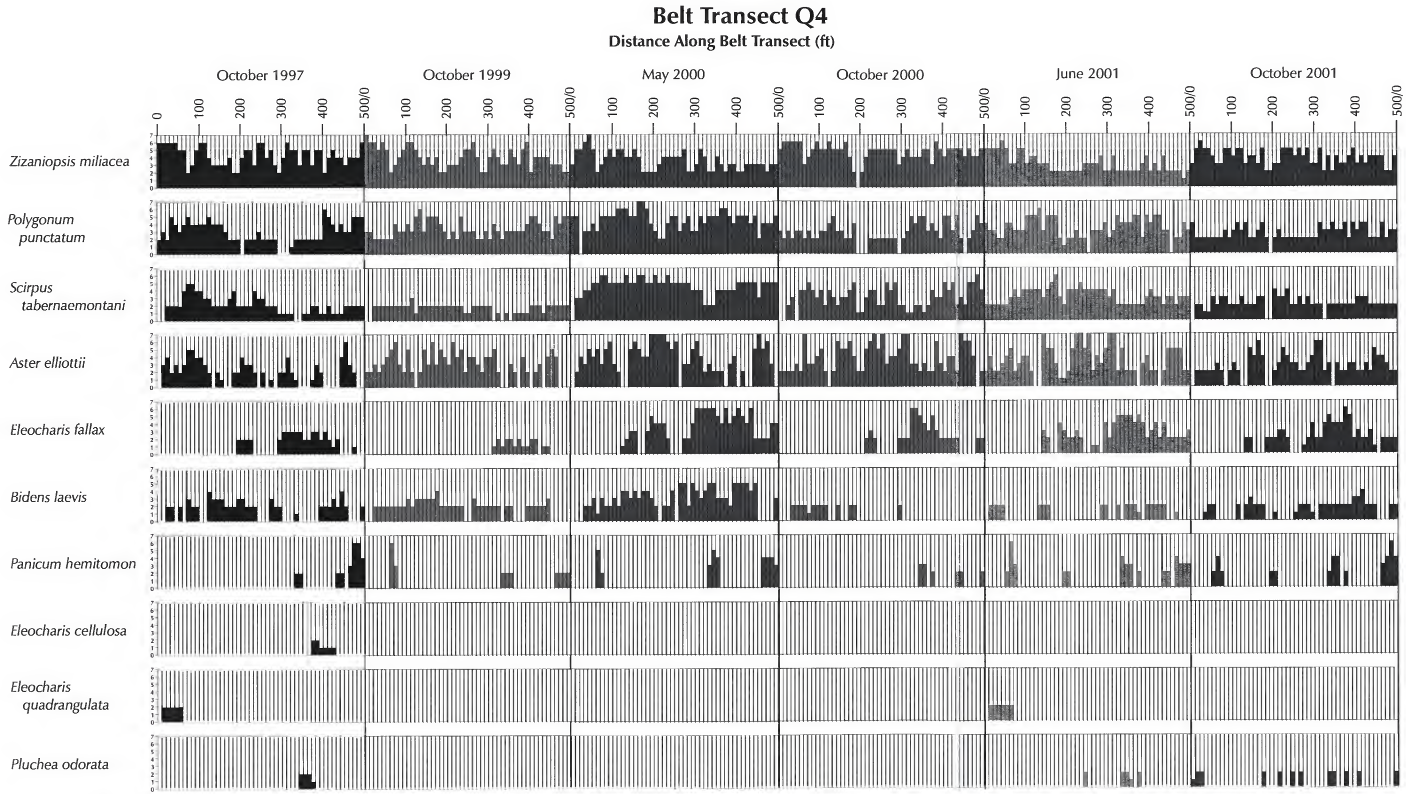


Figure 3-18. Belt transect Q4 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

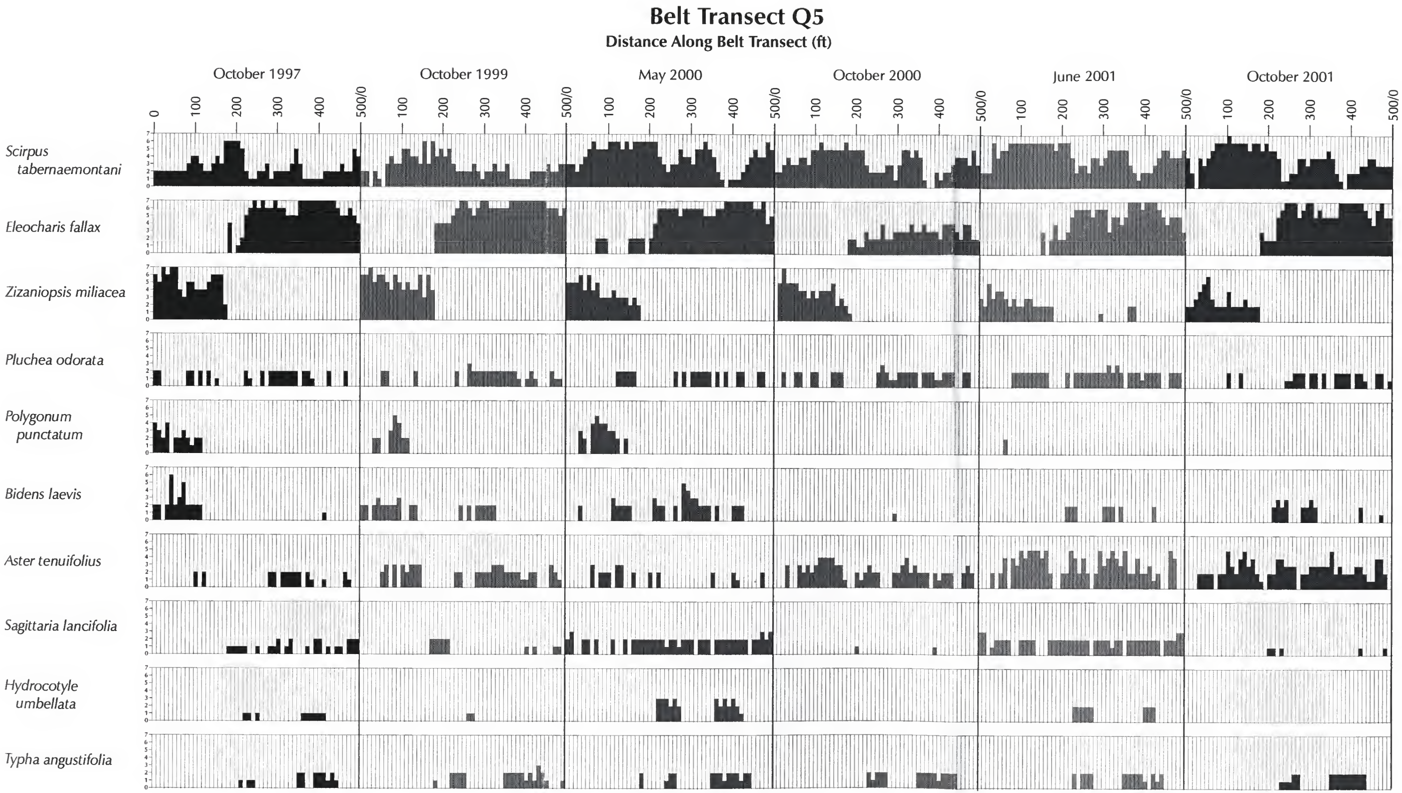


Figure 3-19. Belt transect Q5 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

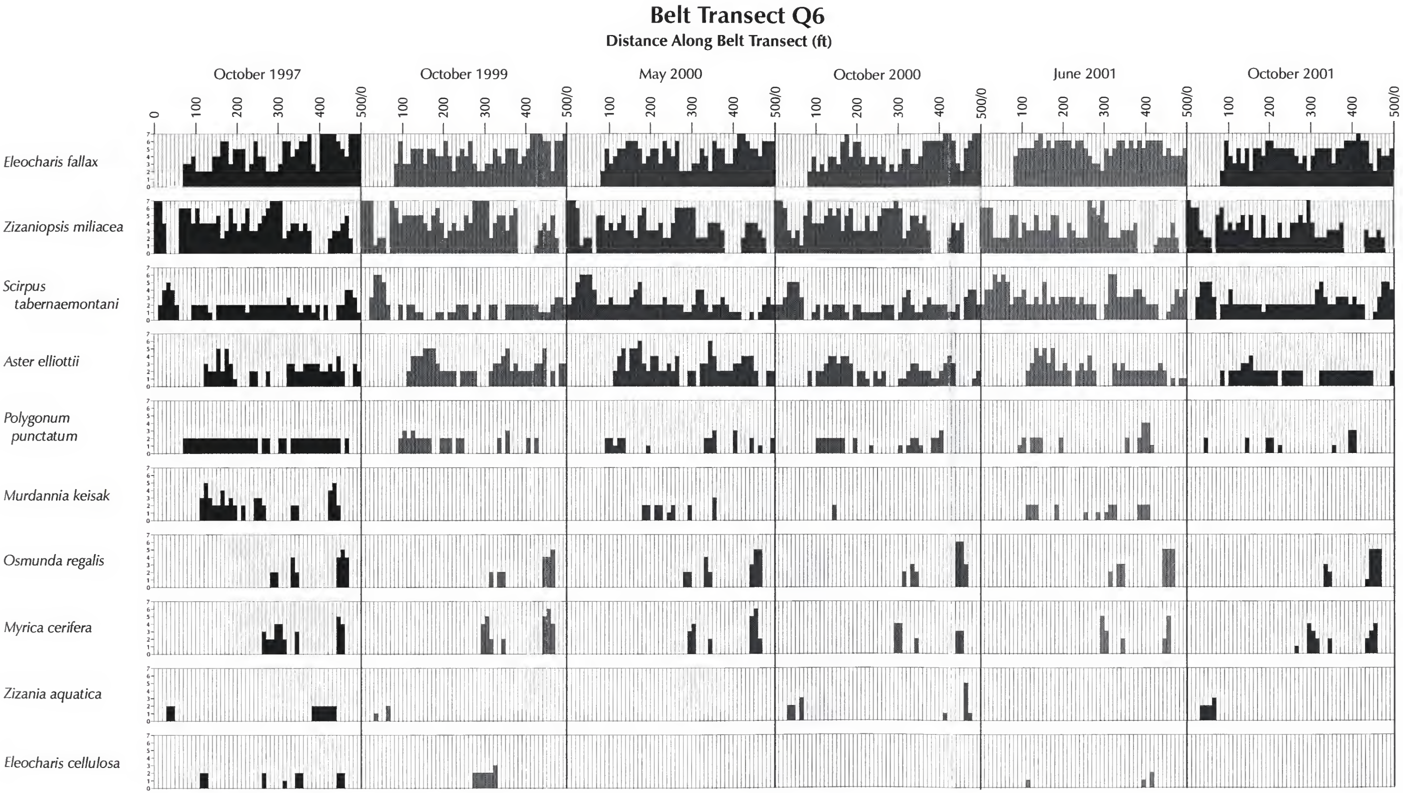


Figure 3-20. Belt transect Q6 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

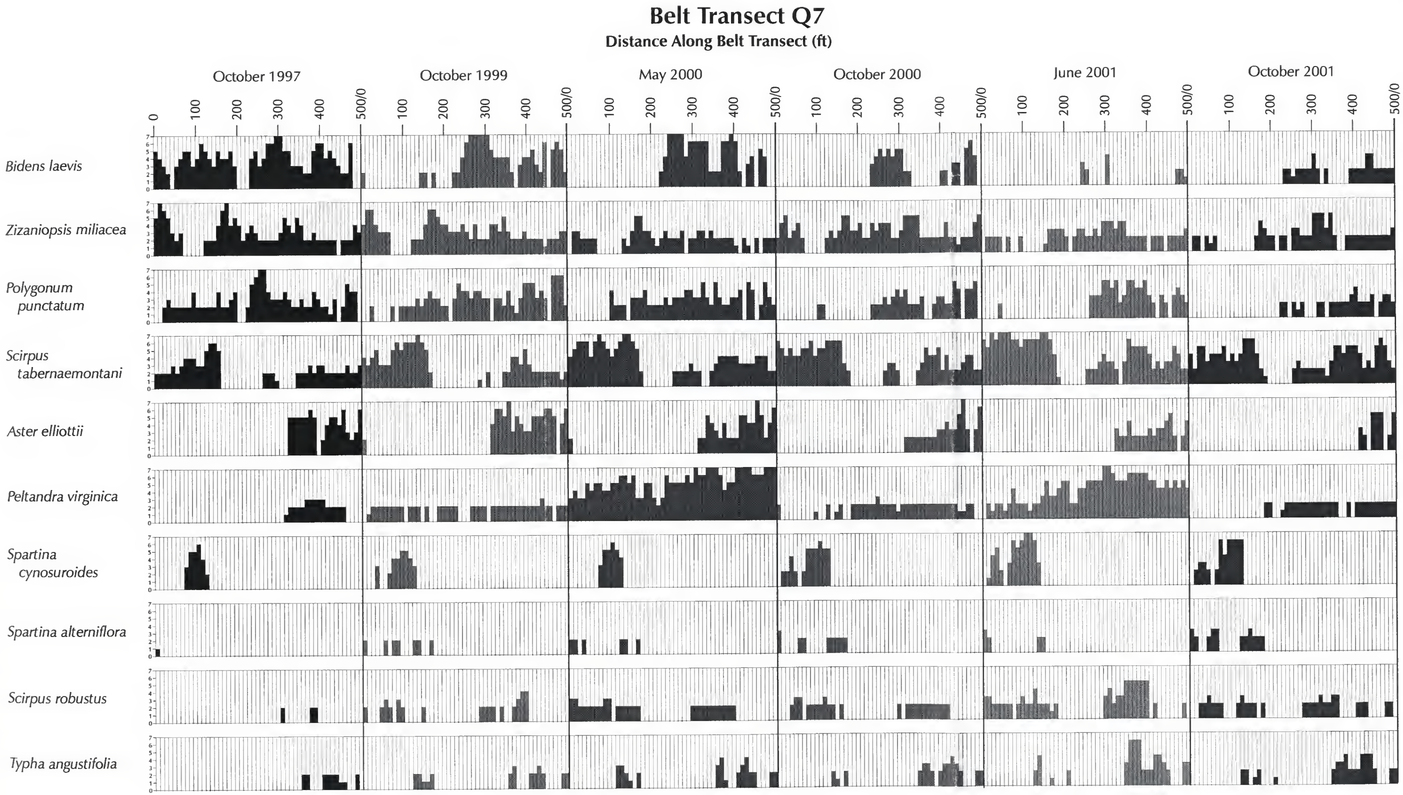


Figure 3-21. Belt transect Q7 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

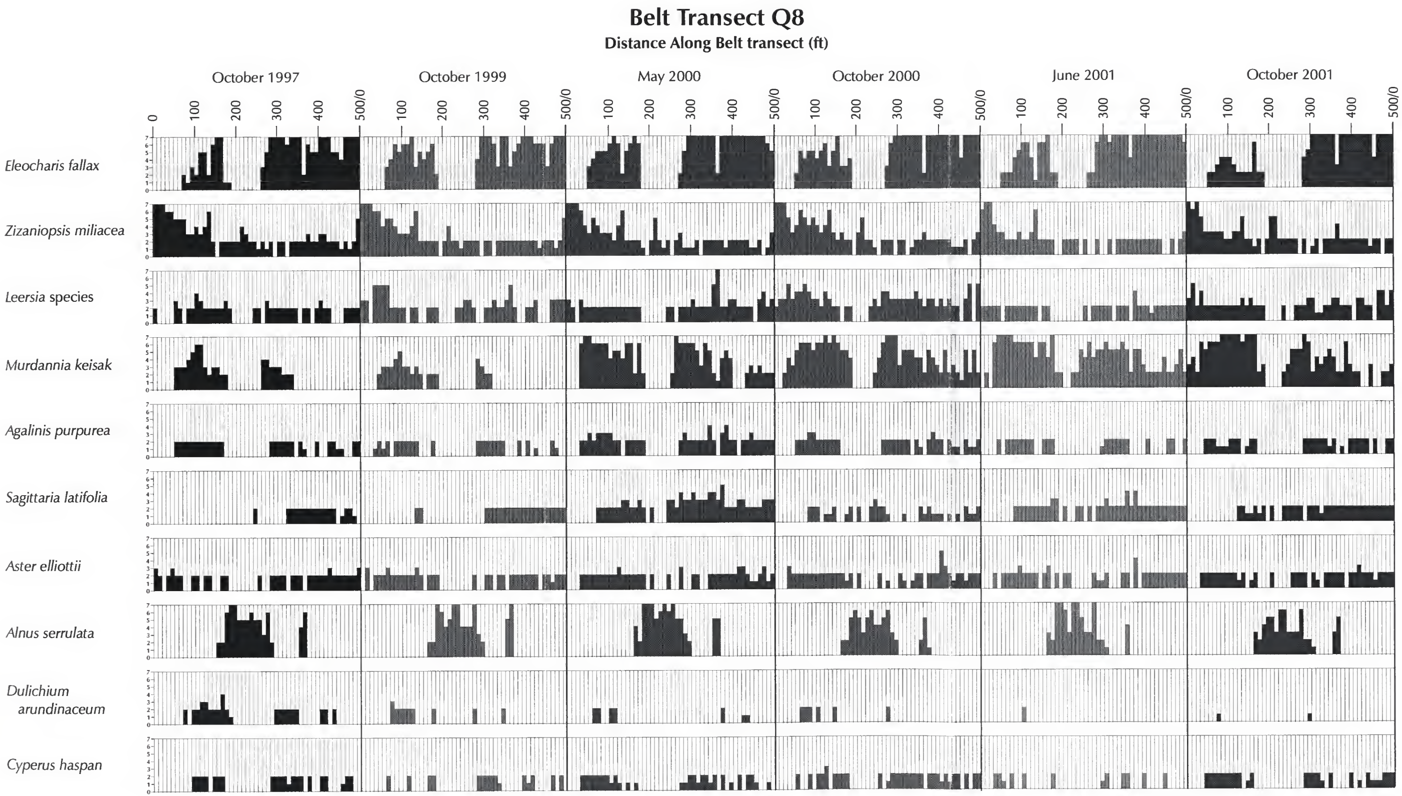


Figure 3-22. Belt transect Q8 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

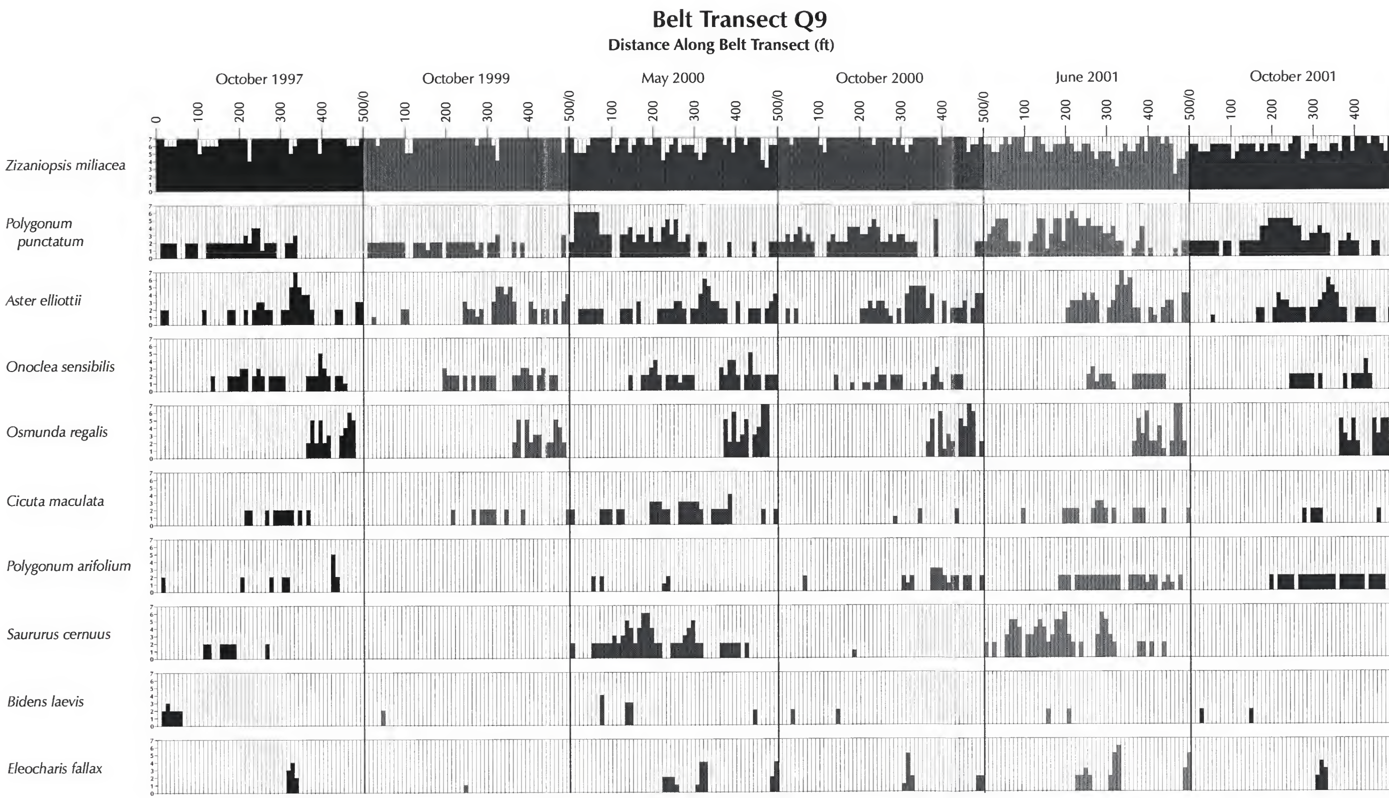


Figure 3-23. Belt transect Q9 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997, October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

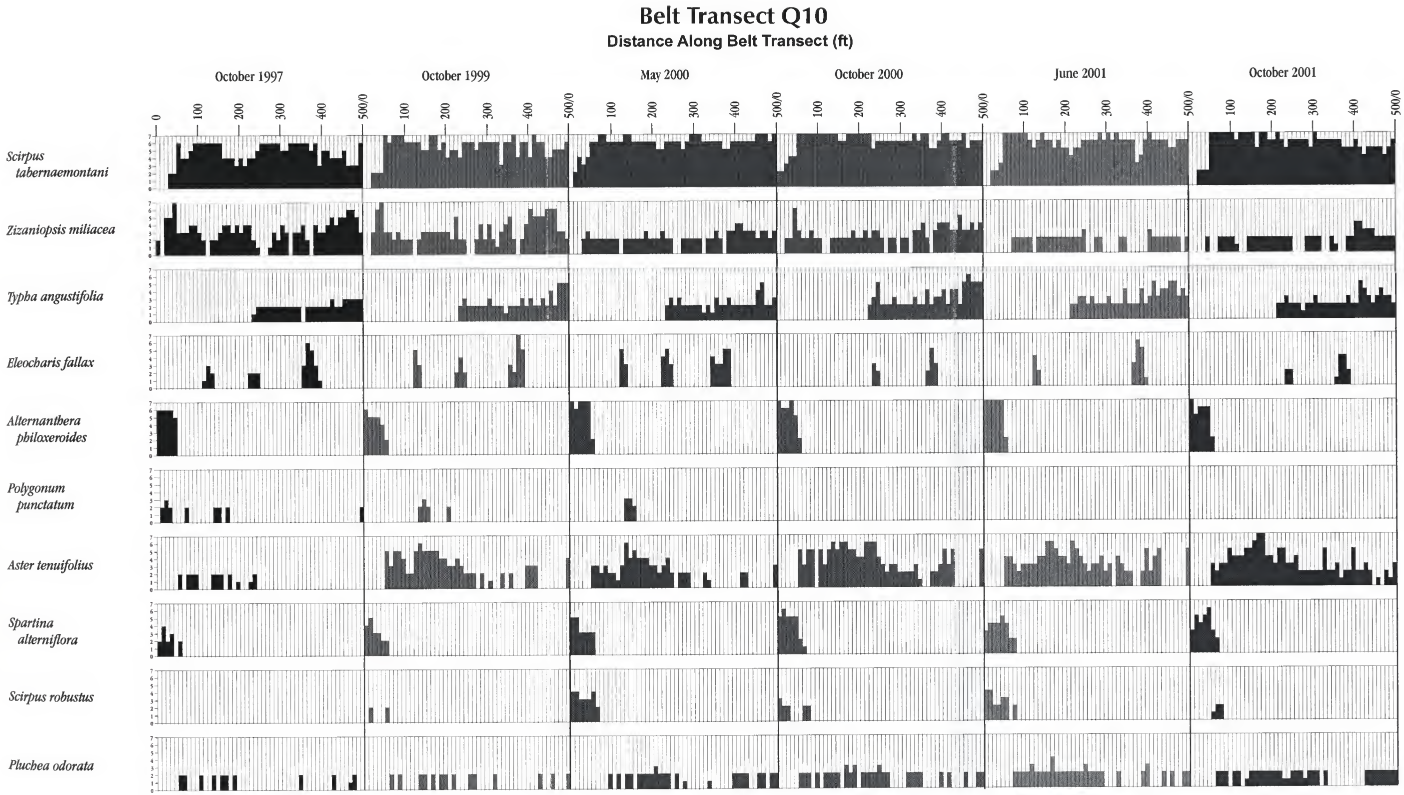


Figure 3-24. Belt transect Q10 cover values of the top ten plant species established in the unimpounded marshes of the Savannah National Wildlife Refuge during October 1997,October 1999, May 2000, October 2000, June 2001, and October 2001. Species are ranked based on the frequency distribution of each species during the October 1997 sampling event.

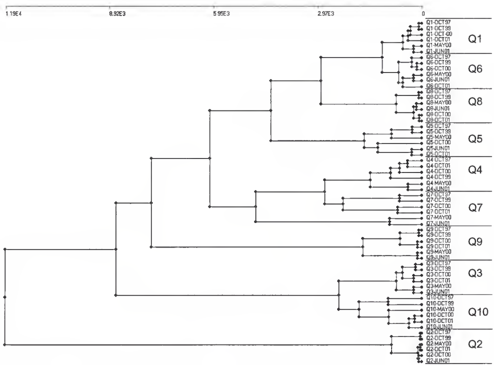


Figure 3-25. Cluster analysis for the ten most common species occurring for all sampling events for all belt transects.

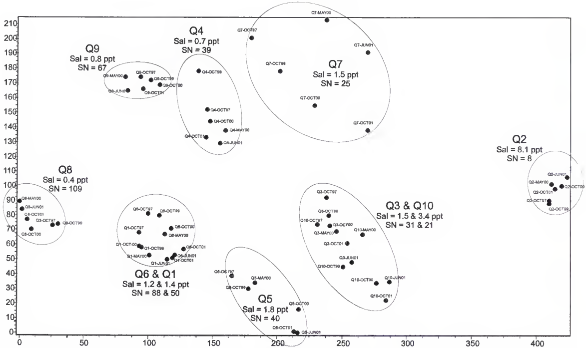


Figure 3-26. Detrended correspondence analysis based on belt transect scores (Sal = Salinity, ppt; SN = species number)

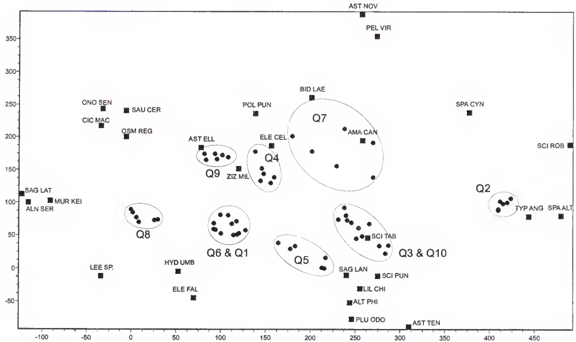


Figure 3-27. Detrended correspondence analysis based on species scores (Sal = Salinity, ppt; SN = species number)

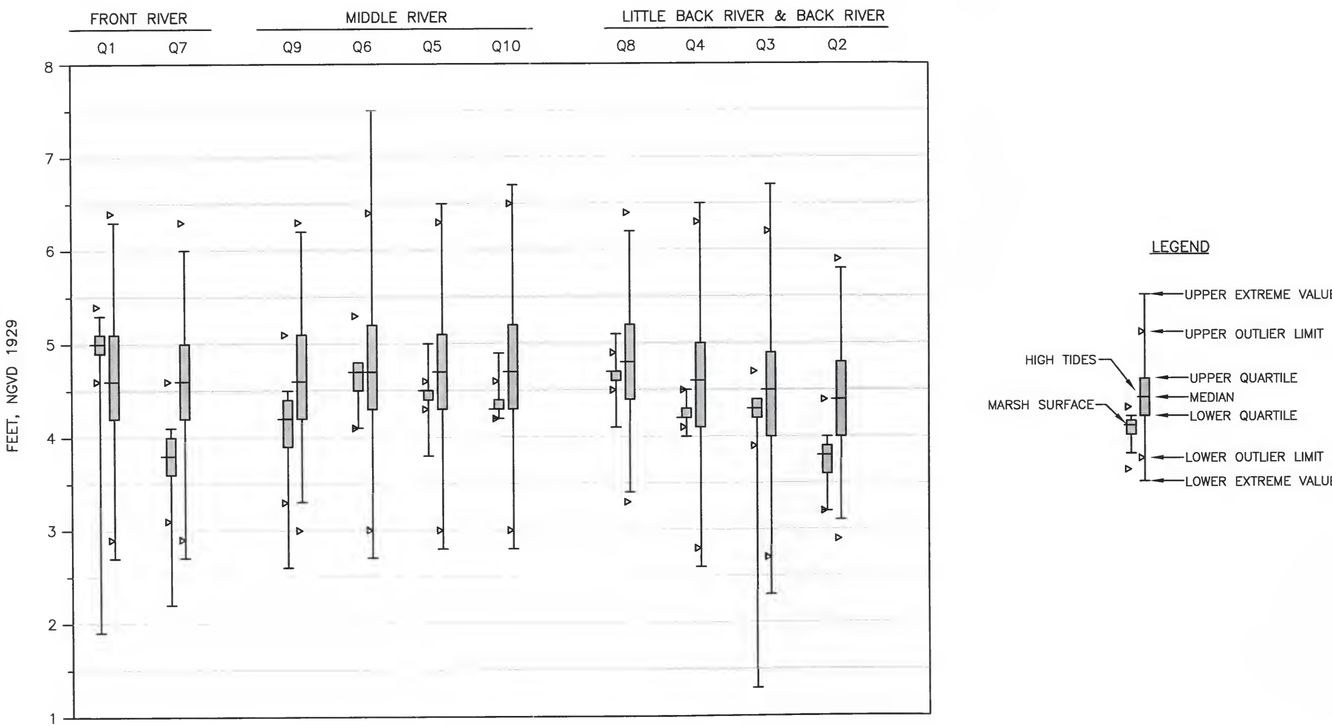


Figure 3-28. Box plots comparing marsh surface elevations at the 10 belt transects to the high tide elevations as recorded in the adjacent tidal creeks.

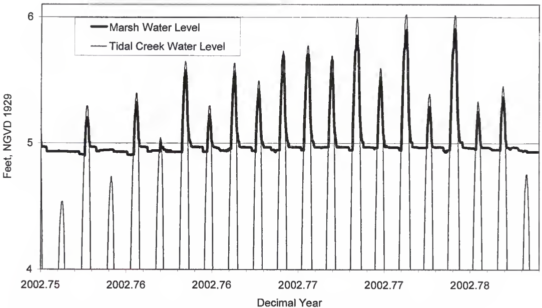


Figure 3-29. Belt transect Q1 comparison of water levels between tidal creek and marsh interior.

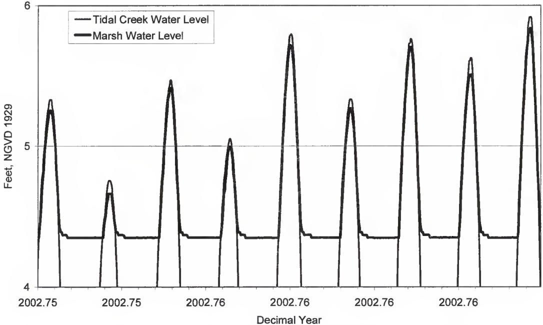


Figure 3-30. Belt transect Q10 comparison of water levels between tidal creek and marsh interior.

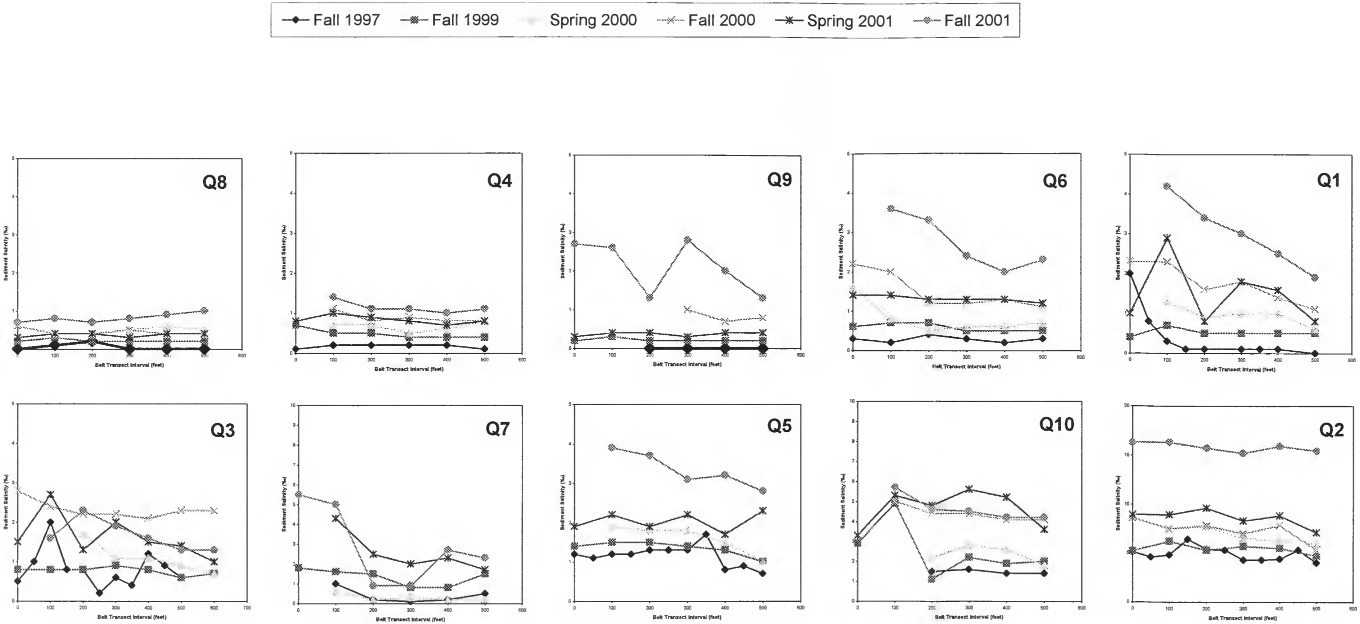


Figure 3-31. Sediment salinity for each of the ten belt transects.

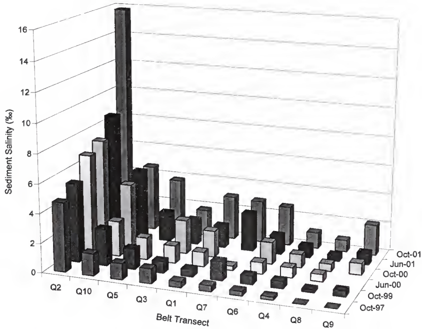
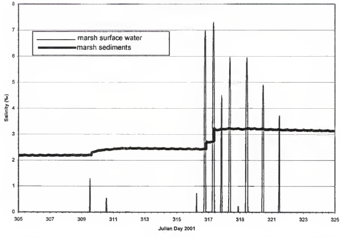


Figure 3-32. Average sediment salinity within each of the ten belt transects during each sampling event.



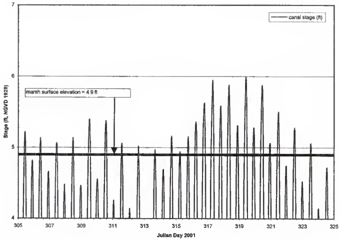


Figure 3-33. Q1 comparison of sediment salinity changes and tidal regime (November 1, 2001 - November 21, 2001).

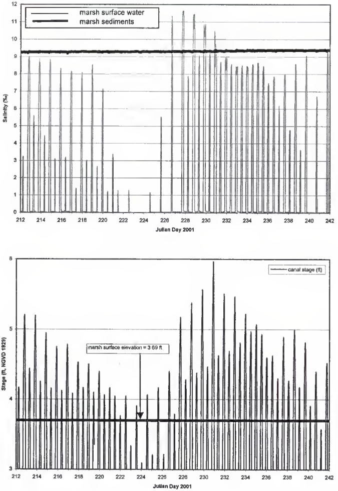
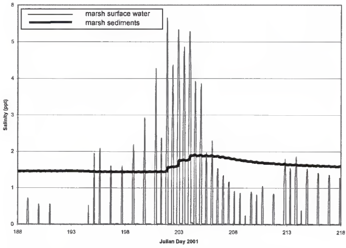


Figure 3-34. Q2 comparison of sediment salinity changes and tidal regime (July 31, 2001 - August 30, 2001).



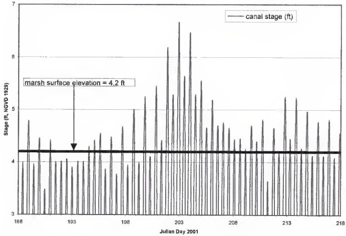


Figure 3-35. Q3 comparison of sediment salinity changes and tidal regime (July 7, 2001 - August 6, 2001).

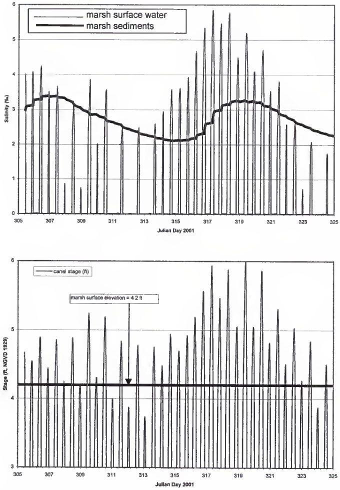
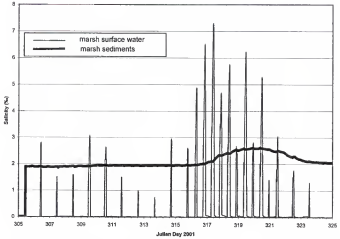


Figure 3-36. Q3 comparison of sediment salinity changes and tidal regime (November 1, 2001 - November 21, 2001).



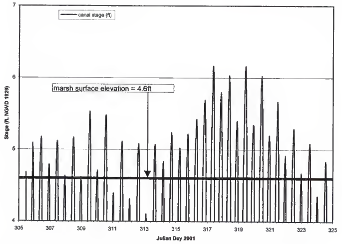


Figure 3-37. Q6 comparison of sediment salinity changes and tidal regime (November 1, 2001 - November 21, 2001).

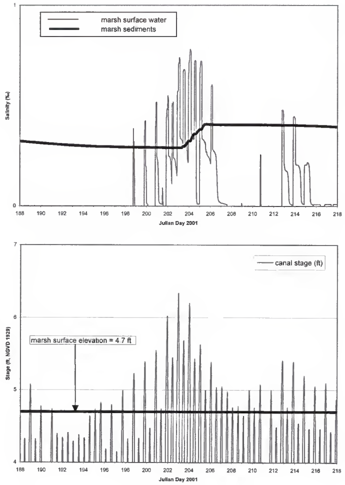
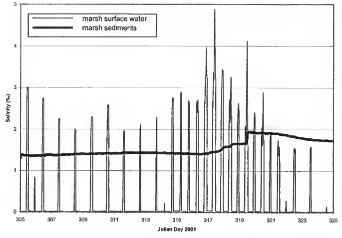


Figure 3-38. Q8 comparison of sediment salinity changes and tidal regime (July 7, 2001 - August 6, 2001).



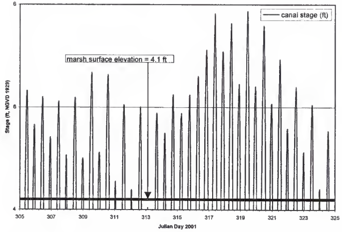


Figure 3-39. Q9 comparison of sediment salinity changes and tidal regime (November 1, 2001 - November 21, 2001).

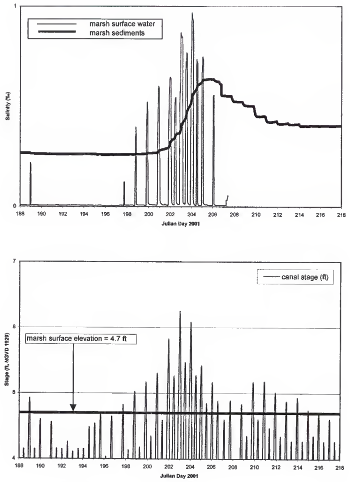
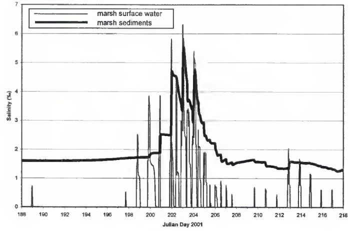


Figure 3-40. Datalogging station E comparison of sediment salinity changes and tidal regime (July 7, 2001 - August 6, 2001).



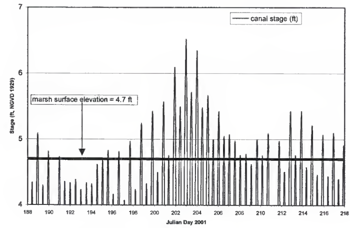


Figure 3-41. Datalogging station W comparison of sediment salinity changes and tidal regime (July 7, 2001 - August 6, 2001).

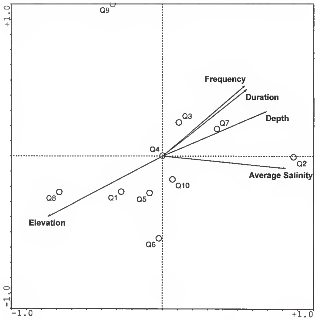


Figure 3-42. Detrended canonical correspondence analysis biplot relating relative frequency plant data to five environmental variables.

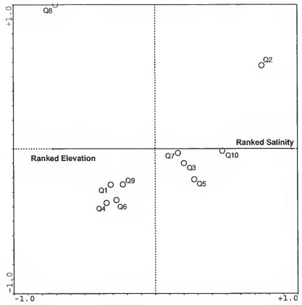


Figure 3-43. Detrended canonical correspondence analysis biplot relating relative frequency plant data to ranked elevation and salinity.

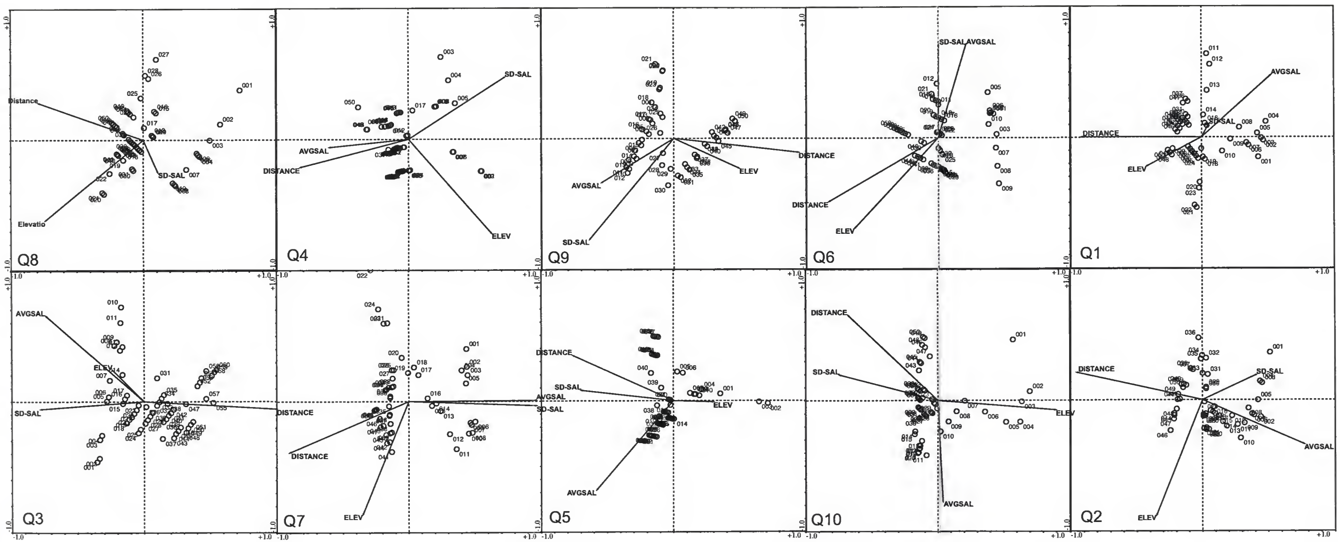


Figure 3-44. Detrended canonical correspondence analyses for the ten belt transects.

CHAPTER 4
DISCUSSION

Figure 4-1 provides a systems diagram relating tidal marsh plant community structure of the upper Savannah River estuary to salinity and hydrologic gradients. The diagram is divided into two main compartments, the estuary and the tidal marsh, to provide a conceptual differentiation between the vegetated areas of the marsh and the open water areas of the estuary where the salinity and hydrologic gradients originate. Starting along the left boundary of the diagram, ocean salt carried upriver by the rising tide interacts with the freshwater river flow to generate the estuarine salinity gradient, which is represented by the river and tidal creek salinity. Salinity within the river channels is carried into the tidal creek system and over the marsh surface when the high-tide level is of sufficient magnitude. Changes in sediment salinity within the tidal marsh reflect an interaction between the salinity of marsh floodwaters and the marsh stage. Marsh stage, or the depth of surface water over the marsh at any given time, may be influenced by both tide and wind, which enter the system along the left boundary of the diagram. Wind may influence marsh stage when sustained onshore winds of sufficient magnitude hold the high tide on the marsh for extended periods and facilitate short-term, but sometimes substantial, increases in sediment salinity.

Along the top boundary of the tidal marsh compartment, rainfall input onto the marsh surface may cause subsequent decreases in sediment salinity. Further, particulates and eroded sediments carried by the flowing river are transported into the marsh interior by the flooding high tide, where they settle-out through sedimentation. Changes in marsh surface elevation are caused by an interaction between the plant community structure at any given location and the sediment source at that location. Plant stems slow the flow of water across the marsh surface during the rising tide, resulting in heavier particulates settling first and the lightest particulates being carried farthest across the marsh. While not specifically tested in this study, clay sediments may be flocculated by salinity (Day et al. 1989), leading to substantial differences in sediment consolidation and porosity (Bohn et al. 1985). In contrast, clay sediments under freshwater conditions may be dispersed. Marsh surface elevation in relation to marsh stage defines the inundation depth, duration, and frequency.

Plant community structure is contained within the primary producer symbol, labeled *PLANTS*, located in the lower left quadrant of the tidal marsh compartment. In the systems diagram, changes in plant community structure are the result of interactions between sediment salinity, the hydrologic factors of tidal inundation depth, duration, and frequency, and the feedback from the existing plant community structure. As sediment salinity levels increase above 0.5‰, salinity plays a more dominant role in defining community composition. As salinity drops below 0.5‰, the feedback component expressed is interspecies competition becomes increasingly important in defining community composition.

Table 4-1 provides a summary of selected parameters that differentiate the belt transects.

Table 4-1. Summary of belt transect parameters.

	River Mile	Average Sediment Salinity ± Std Dev	Inundation Depth (feet)	Inundation Duration (%)	Inundation Frequency (%)
Front River:					
Q1	23.5	1.2 ± 1.0	0.2	9	35
Q7	22.0	1.5 ± 1.5	0.9	37	94
Middle River:					
Q9	24.0	0.9 ± 0.9	0.6	28	83
Q6	23.5	1.2 ± 0.8	0.2	15	59
Q5	22.5	1.7 ± 0.8	0.2	31	61
Q10	21.5	3.4 ± 1.5	0.3	25	63
Little Back River:					
Q8	24.5	0.4 ± 0.3	0.1	17	56
Q4	21.5	0.7 ± 0.3	0.4	23	73
Q3	20.5	1.4 ± 0.7	0.3	32	65
Back River:					
Q2	17.0	7.8 ± 3.7	0.7	29	90

The former rice field infrastructure has self-organized into a diverse marsh system. The study area was forested with a tidal swamp dominated by cypress and gum prior to clearing for development of rice fields. The presence of the tidal forest at that time reflected environmental gradients existing prior to the extensive changes associated with development of the rice fields. In turn, the marsh vegetative cover, as it exists today, reflects the suite of environmental gradients that have become established since abandonment of the former rice fields. The study area and its surroundings have followed a history of intense industrial development, population growth, and conflicting marsh management objectives. In addition to these agricultural and development changes, hydrologic and salinity gradients that existed in the pre-rice field era have shifted

over time in response to relative sea-level rise, which both increases water depths and shifts the upriver projection of the salinity gradient.

Comparison of historical maps with current aerial photography documented the transition of the former rice field water supply canals into the existing tidal creek network. Differences in the extent of tidal creek development between the Little Back River and the Middle River may be attributable to higher sedimentation rates in canal sections closer to the Middle River versus the Little Back River. Hydrodynamic modeling results (Applied Technology & Management, Inc. 2002. WQMAP unpublished model test runs. Prepared for Georgia Ports Authority.) show the velocity of the Middle River to be higher than that of the Little Back River indicating the Middle River can potentially carry a higher sediment load and larger particles than the Little Back River (Figure 4-2). As these larger particles are carried from the Middle River into the former water supply canals, any decrease in water velocity would allow them to settle and accumulate. Sediment accumulation would create a hydraulic constriction, further reducing water velocities, exacerbating sedimentation, and creating a blockage that would in time be covered with and stabilized by vegetation.

The sedimentation within the former rice field ditches has resulted in the independent tidal creek systems that currently exist. Since each of these systems is supplied by water from only one point along one of the main river channels, the salinity from a particular point along the riverine salinity gradient can be projected over a large area of marsh. Figure 4-3 provides a schematic of the tidal creek systems on both Arygle Island and Ursla Island and outlines polygons representing the area of influence of each tidal creek or creek system.

Polygon boundaries are simply the midpoints between two adjacent creek networks. These polygons represent the source of surface waters that flood the marsh at high tide. The source of the surface water in turn represents the spatial control of salinity distribution across the marsh surface. As with salinity, the tidal creeks and polygons also control the distribution of suspended sediments to the marsh and influence where they settle.

Sedimentation was responsible for the transformation of the former rice field squares into the existing marshes. Since abandonment, the former squares have filled with tidally transported sediments so that the marsh surface that exists today is several feet higher than the ground elevation of the former rice fields. Dense stands of Z. *milia*ceae growing on the consolidated sediments of marsh perimeters in the freshwater and oligohaline zones are located on areas that were once the perimeter embankments of the rice fields. The density of Z. *milia*ceae stems slows the incoming tidal floodwater, resulting in heavier particles settling from the water column and further increasing the width of the consolidated sediment zone. The only particles remaining (if any) in water transported to the interior of the former square would be small and light, such as clays, where they accumulate as unconsolidated sediments. If ground elevation of the rice fields was approximately 1 to 2 feet (based on survey measurements made in the maintained duck impoundments) and the present elevation of the existing marsh is approximately 5 feet (using the surveyed cross-section of belt transect Q8 as an example, see Figure 3-12), this indicates approximately 3 to 4 feet of sediment accumulation since the time the fields were abandoned.

Vegetation at any location within the study area marshes represents an integration of the environmental factors present at that location. Sediment salinity and tidal hydrology are identified in this study as the dominant factors to which the vegetation responds.

When discussing the relationship between the estuarine salinity gradient and plant species distributions, there is a question of what constitutes the normal, or background (Brewer and Grace 1990), salinity of the marsh sediments. Further, the results showed a substantial difference between the long-term average sediment salinity at a location and infrequent, but short-term, salinity extremes. The gradual shift in vegetation toward more saline assemblages at belt transects Q7 and Q10 points to the overriding influence of the long-term salinity. Short-term salinity extremes were present within all the belt transects but did not elicit a vegetation response in the 4-year time frame encompassed by the study.

The lack of a direct relationship between the salinity of high-tide floodwater and salinity changes in the underlying sediments suggests a resistance to exchange between the two compartments. Floodwater with a substantially higher or lower salinity than the underlying pore water did not translate into a substantial change in pore water salinity during the associated tidal cycle. The physical barrier presented by the tightly intertwined root mat may inhibit mixing between the sediment pore water and the water flooding the marsh surface at high tide. Salinity and temperature differences between water in the two compartments may also inhibit exchange (e.g., cooler, saline water would be denser than warmer, less saline water).

The most substantial deviations from mean sediment salinity were associated with infrequent extended high tides that held water on the marsh for several days at a time. These occasional extended tides were generated by meteorological events, specifically nor'easters, characterized by several days of strong onshore winds that pushed water upriver. Figures 3-33 through 3-41 provided a comparison of marsh surface water salinity versus salinity of the underlying sediments. Each figure provided an example of tidal conditions that resulted in a relatively substantial, but short-term, increase in sediment salinity at all locations except belt transect Q2 (Figure 3-34), which was the most saline of sample sites. The salinity of the water flooding the marsh during high tide was always higher than the salinity within the underlying sediments. Increases in sediment salinity occurred with a lag time so that sediment salinity levels peaked from 2 to 5 days after the initial tidal events that generated the increase in sediment salinity. These peak sediment salinity values were always substantially lower than the surface water salinity levels, but if the upward trend would have continued would have required approximately 10 days to reach 50% of the peak surface water salinity level. This 10-day time lag provides a buffer to the routine short-term fluctuations in salinity of the marsh surface waters that cover the marsh during high tides.

While the elevated sediment salinities graphed in Figures 3-33 through 3-41 were short-lived, the ability of sediments to integrate salinity exposure over multiple years was demonstrated by the steadily rising sediment salinity values recorded within the vegetation monitoring belt transects after the initial sampling in late 1997 (Figures 3-31and 3-32).

The increasing sediment salinities were caused by a regional drought that began in late 1998 and extended through the duration of the study period. The daily river flows recorded at the Clyo gaging station during 1997 (Figure 1-7) and the years prior (Figure 1-6) were near the expected averages. The preceding several years of normal river flows suggests the salinity values recorded in the marsh sediments during the initial 1997 vegetation sampling were representative of the average, or background, sediment salinity values for those locations under non-drought conditions. While a wet winter and spring produced higher than normal flows during the first half of 1998, since early 1999 flows in the Savannah River were substantially below normal and many times approached or dropped below the previously recorded minimums. The low flows since late 1998 allowed the tidal salinity wedge to intrude further upriver, raised the salinity of the water that flooded the marshes at high tide, and over time facilitated the accumulation of salt in the marsh sediments and plant root zone.

The rapid changes in sediment salinity resulting from the extended water stage on the marsh were all associated with conditions that resulted in salinity increases. During the nor'easters that occurred during the monitoring period, the salinity in the water over the marsh was always higher than that in the underlying sediments. However, the question remains if dramatic decreases in salinity would have been observed under different meteorological conditions, such as extended, heavy rain with an offshore wind that would keep the tide stage low. These conditions were not present during the study

The tide gate was thought to be responsible for raising sediment salinities during its period of operation from 1977 through 1992 (Pearlstine et al. 1993). If

the salinity values measured during the fall 1997 vegetation sampling were to be considered as representative of the background, or baseline, salinity levels, the assumption had to be made that the marsh sediment salinity levels had recovered and stabilized in the intervening 5 years since the 1992 decommissioning of the tide gate. This assumption was supported by field tests conducted by Pearlstine et al. (1990) prior to tide gate decommissioning. From these tests, Pearlstine et al. (1990) estimated that complete recovery of sediment salinity levels would occur within 2 months of tide gate removal. In addition, reduction in sediment salinity after tide gate removal would have been further facilitated by an unusually wet winter in 1992-1993 (Figure 1-6).

While sediment salinity was a dynamic abiotic factor with easily measured differences, the response of the plant communities to changes in salinity was not as pronounced. Empirically, a rising salinity in a freshwater or low-salinity oligohaline portion of the marsh leads to decreasing species richness as plants with low salt tolerance are killed outright or fail to germinate in the following season. This provides the opportunity for the remaining plants with somewhat higher salt tolerance to increase in abundance, or for additional salt tolerant species to become established. With a few exceptions, most notably *S. alterniflora* and *S. cynosuroides*, the plant species that dominate the oligohaline portions of the marsh study area are also common species in the most freshwater marsh areas. Most of the species that dominate the oligohaline areas are also common freshwater marsh species; however, the freshwater marsh is characterized by the presence of a number of species that are not found in higher salinity situations. For example, belt transect Q8, the least saline of the

belt transects, also had the highest species richness, with 109 species identified over the course of the study (Table 3-5). Of these 109 species, 30 were found only within Q8, however, many of these species were occasionals identified only once or twice during the six sampling events.

Despite their spatial proximity to one another on northern Argyle Island, there is a substantial difference in the total species richness between Q8 with its 109 species, and Q6 and Q9, which had 68 and 67 species respectively. The spatial differences in the sediment salinities at the E and W datalogging stations demonstrated the substantial differences in sediment salinity that can exist over a short distance within the marsh. The species counts during each of the vegetation sampling events (Table 3-5), as well as the DCA plots, indicated there was no downward trend in species numbers occurring at Q6 or Q9 over the course of the study. Accordingly, the difference in species numbers between Q8 and Q6 and Q9 cannot be attributed to drought induced salinity affects. However, Q6 and Q9 are located along the Middle River, while Q8 is along the Little Back River, which has less exposure to transient salinity increases. As discussed above, the sediment salinity levels measured during the fall 1997 sampling are considered indicative of average, nondrought conditions. In 1997, Q6, Q8, and Q9 all had sediment salinity levels less than 0.5‰ (Figures 3-31 and 3-32). Since the initial sample, sediment salinity levels have steadily increased at all locations in response to the drought, but with no vegetation response. The vegetation assemblages at Q6 and Q9 are already tolerant of the salinity impinging on their locations during the drought, and at the same time reflect salinity conditions present prior to the drought. They may provide an example of

the resistance to a community response to the short-term salinity increases discussed above.

Of all the belt transects, Q8 had the most unique species (Table 3-5). The absence of salt stress in combination with the well-developed root mat at Q8 may facilitate germination of the occasionals by providing an appropriate germination substrate. While the marsh sediments at Q8 are always saturated, they are rarely flooded very deeply for very long. During periods the root mat is not inundated the surface layer is able to remain more aerobic, perhaps by draining slightly, than the constantly saturated underlying sediments. These conditions have been shown to facilitate germination of annuals, which are generally not tolerant of flooding (Brewer and Grace 1990). Howard and Mendelsshon (2000) noted that seed germination of annuals is enhanced under non-flooded conditions.

Higher species richness is one characteristic that differentiates the most highly diverse tidal freshwater marsh, such as found at belt transect Q8, and slightly oligohaline areas, such as those in the vicinity of belt transects Q6 or Q9. Species richness continues to decline with increasing average salinity. As salinity is increased in a freshwater area, the decline in species richness is probably fairly rapid (Figure 4-4). While even low salt concentrations may kill salt intolerant plants quickly, a subsequent reduction in the average sediment salinity may not necessarily lead to a rapid increase in species richness. Brewer and Grace (1990) identified infrequent, storm-generated salinity pulses as the driving force in plant distributions in their study of oligohaline marsh community structure along a river in Louisiana. At their study sites, the vegetative zonation was not

correlated with average soil salinity, but was instead correlated with distance upriver from the estuary, with salt tolerant plants dominating near the river mouth and shifting to more freshwater assemblages upriver. The salinity driven upriver by the storm events would attenuate with distance. Since the salinity pulses were temporary, soil salinities would decrease to their former lower levels. Their study did not address the magnitude of the sediment salinity levels generated by the storm pulses, the duration of elevated salinity, or the amount of time required for sediment salinities to drop to their previous levels; however, the salt pulses were characterized as short-term. Salt tolerant species selected for by the salt pulses would be gradually replaced by less salt tolerant, but more competitive, species as the time between salt pulses increased; however, the authors suggested this replacement would occur over a time scale of years or decades, and not over a few seasons.

Howard and Mendelssohn (2000) found a 3-month salinity exposure at 12‰ with concurrent flooding to either 1- or 15-cm resulted in community level changes in their study of oligohaline marsh structure. Changes did not occur with only 1-month salinity exposure. Community changes were not the result of recruitment of brackish species, but rather the differential response of existing species present either as rhizomes or seed bank (Howard and Mendelssohn 2000). If disturbance or stress conditions were severe enough to eliminate a substantial portion of the existing vegetation, development of a new community structure was dependent on colonization conditions (e.g., seedling density, temporal preemption, or spatial heterogeneity) (Howard and Mendelssohn 2000).

Evaluation of the comparative importance of salinity pulses versus the long-term average sediment salinities in influencing the marsh community structure in the Savannah River study area must consider ongoing community changes that may have been occurring since decommissioning of the tide gate. Pearlstine et al. (1990), Latham (1990), and Pearlstine et al. (1993) attributed high-salinity levels resulting from tide gate operation as the cause of massive community changes in tidal freshwater marshes, which were said to extend downriver nearly as far as the tide gate. Tide gate operation was reported to have replaced the freshwater marshes with lower diversity oligohaline and mesohaline communities dominated by *S. tabernaemontani* (formerly *Scirpus validus)*. Decommissioning of the tide gate, and the subsequent reduction of sediment salinity levels, was reported to be facilitating re-establishment of tidal freshwater communities (Latham and Kitchens 1996).

The temporal DCA indicated that, since the initial vegetation sampling in 1997, only belt transects Q7 and Q10 underwent directional community shifts toward more salt tolerant assemblages. Based on the steadily increasing sediment salinities at these locations, these community shifts represented a response to the drought. Despite increased sediment salinities at other locations, the lack of a directional pattern in the DCA plots of the remaining belt transects suggested these assemblages have not changed as a result of the drought. Temporal differences between the scores for these belt transects represent simple seasonal and annual variation in the community assemblages.

The temporal differences between the DCA scores at belt transects Q7 and Q10 indicate that the DCA plot is an effective analysis tool to determine

which of the sample belt transects are sensitive to salinity induced changes. The drought response noted at belt transects Q7 and Q10 indicate that salinity thresholds had been exceeded at these locations. Vegetation within the other belt transects has remained within their salinity tolerance thresholds. Although belt transect Q2 experienced a greater drought induced salinity increase than either belt transect Q7 or Q10 (Figure 3-32), vegetation at Q2 did not change. The lower species richness at Q2 indicates this area of the marsh is already tolerant of the salinity levels generated by the drought and that the drought increases were not sufficient to raise sediment salinities to levels that would eliminate all but the most salt tolerant species, in this case *S. alterniflora*.

Perry and Hershner (1999) suggested that perennials were better indicators of directional community changes than annuals. Annuals were cited as more opportunistic in distribution and therefore had wider variations in abundance based on chance. Conversely, once established, perennials were more persistent and integrated environmental conditions over greater time periods, making them more useful as indicators of directional community change.

This observation was supported by a 10-year study of population fluctuations in tidal freshwater high marsh vegetation conducted by Leck and Simpson (1995). They found persistence of the same suite of species but significant year-to-year fluctuations in dominance among the annuals, which comprised 80 to 90% of the cover. The dominant annual species in a given year could not be predicted from the previous year's vegetative cover or the seed bank, and germination success did not guarantee establishment in a given year.

However, the dominant perennial, *Peltandra virginica*, was consistent from year to year.

An alternative explanation of the stability of the plant assemblages within a majority of the belt transects is that their recovery toward a more freshwater assemblage following decommissioning of the tide gate has been arrested by the rising sediment salinity levels caused by the drought. Therefore, the response to the drought within these belt transects is manifested not as a shift toward more salt tolerant vegetation, but instead as the lack of further recovery toward a more freshwater community. Consequently, the plant assemblages at these locations are already tolerant of the salinity levels they have been exposed to. While the species assemblages at these locations are stable within the range of salinities recorded during this study, the presence of any salinity reduces the potential for interspecies competition. Interspecies competition has been cited (Brewer and Grace 1990, Latham 1990, Perry and Hershner 1999) as the dominant factor affecting species distributions in tidal freshwater marshes. The lack of salt stress in the freshwater environment allows interspecies competition to prevail, facilitating development of the substantially higher species richness found at Q8 versus the other belt transects. Shifting of the average salinity to even the low end of the oligohaline range (i.e., 0.5‰) introduces salt stress that substantially limits the expression of species richness. This is consistent with Latham (1990) who concluded that competition was more important in low-salinity environments than in higher salinity, higher stress environments.

In addition to the drought effects, sea-level rise also contributes to the existing salinity regime. With a local sea-level rise of approximately 1 foot per

century, average water levels are up to 0.3 feet higher than immediately prior to the start of tide gate construction in the early 1970s, and perhaps nearly 3 feet higher than at the beginning of the tidewater rice industry in the early 1700s. A higher average water level allows the salinity gradient to extend further upriver, raising the average salinity in the river channels and ultimately in the marsh sediments. This conclusion is consistent with findings of Perry and Hershner (1999) who studied temporal shifts in vegetative dominance over a 14-year period in tidal freshwater marshes on Chesapeake Bay. Average yearly salinity at the site was approximately 0.45‰ and ranged from 0 to 7‰. The study found an increase in oligohaline-associated species, particularly *Spartina cynosuroides*. An increase in oligohaline conditions was attributed to a relative sea-level rise of 0.013 feet Perry and Hershner (1999) cited the need for studies on the inundation frequency and salt tolerance of individual species in order to predict the rate at which community changes would occur in response to increasing salinity.

Sediment salinities along the estuarine salinity gradient were shown to increase as a result of the drought (Figure 3-31). These drought induced salinity increases would be expected to be reversible and temporary, reflecting the temporal dynamics of wet and dry periods in the rainfall pattern. However, more permanent increases in sediment salinity would be expected in response to long-term sea-level rise. The rate of sea-level rise within the study area was demonstrated through analysis of long-term tide stage data from the Ft. Pulaski gage (Figure 1-25). However, the configuration of the river channels and the associated tidal creek networks were shown to spatially influence salinity levels

within small areas, leading to substantial differences in salinity across short distances within the marsh. The spatial differences in the sediment salinities at the datalogging stations E and W demonstrated the importance of the tidal creek system in controlling salinities across the marshes. Plant distributions within each of the belt transects were influenced mostly by distance from the river channel edge, reflecting differences in sediment type versus strong within site salinity gradients.

Figure 4-3 provided a schematic of the tidal creek systems on both Arygle Island and Ursla Island and outlined polygons representing the area of influence of each tidal creek or creek system. Since these tidal creeks control the salinity distribution across the marsh surface, the polygons within Figure 4-3 could be the basis of a spatial model of salinity dynamics within the marshes.

The wide extent of the tide range and salinity fluctuations in the tidal creeks are in contrast to the restricted tide range and salinity fluctuations documented in the marsh interiors. This indicates that, despite the extreme fluctuations outside the marshes, conditions within the marsh interiors are actually very stable. Resistance to salinity change between the marsh sediments and the overlying water column present during high tides affords even further stability. The overall stability of the system is again demonstrated in the integration of environmental factors provided by the marsh vegetation. Rates of vegetation change have been slow despite the upward trend in sediment salinity since late 1997.

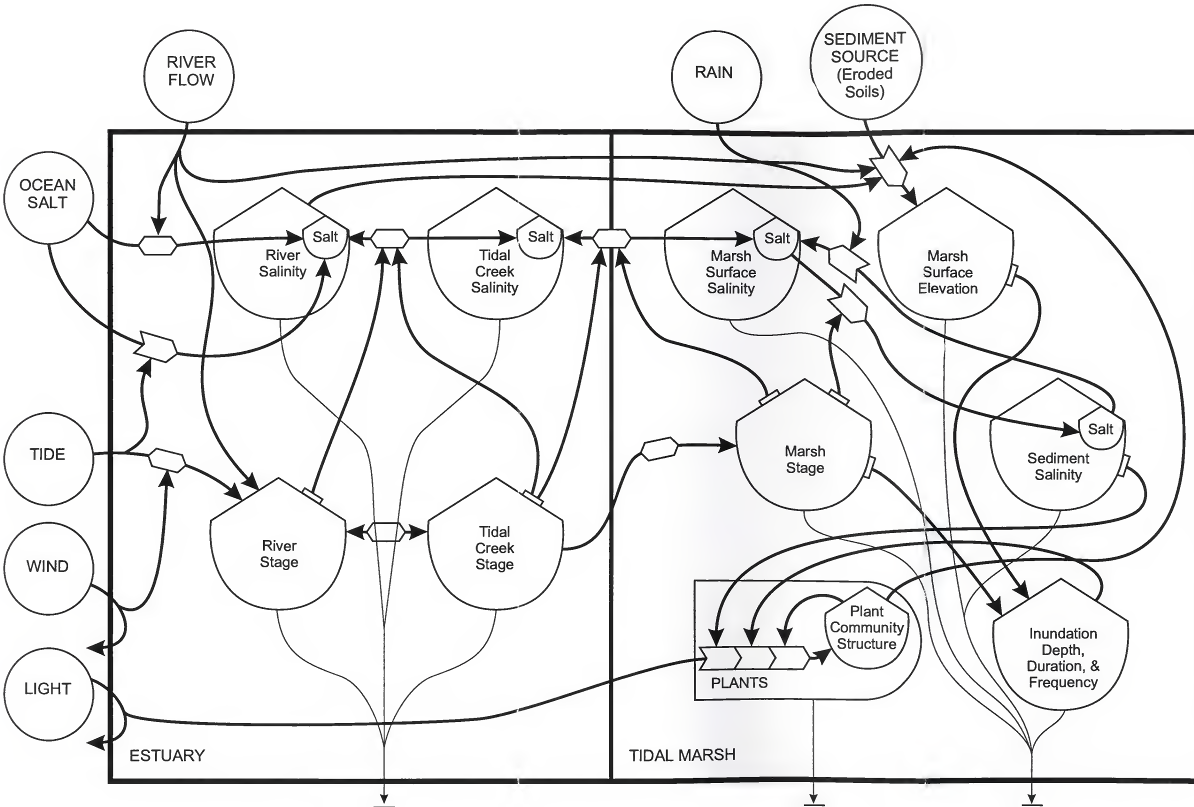


Figure 4-1. Systems diagram relating tidal marsh plant community structure of upper Savannah River estuary to salinity and hydrologic gradients.

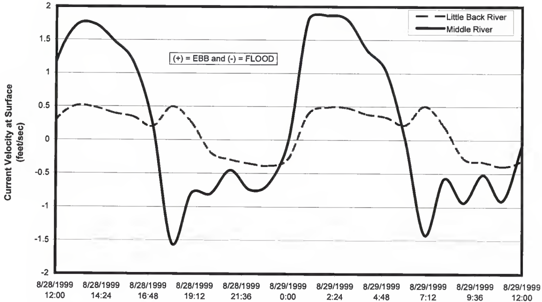


Figure 4-2. Current velocities in the Middle River and Little Back River at the location of the northern main water supply canal. Data generated by a hydrodynamic model.

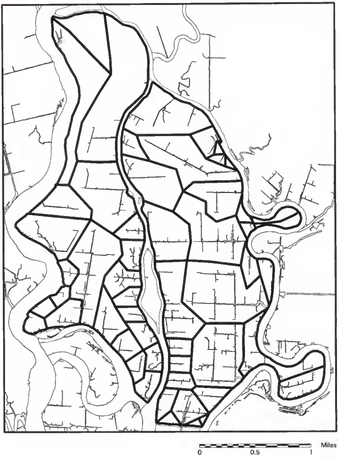
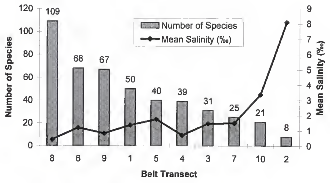


Figure 4-3. Marsh polygons associated with tidal creek system and connections to main river channels.



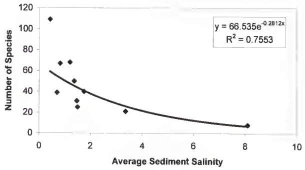


Figure 4-4. Comparison of average sediment salinity and number of plant species found at each belt transect.

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APPENDIX A
VEGETATION DATA

Table A-1. Species codes, scientific name, common name, and presence (X) or absence (–) data for each belt transect by sampling event.

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
1	AGA PUR	*Agalinis purpurea* (L.) Pennell	Gerardia	X	X	X	---	X	X
1	ALT PHI	*Alternanthera philoxeroides* (Mart.) Griseb	Alligatorweed	X	X	X	X	X	X
1	AMA CAN	*Amaranthus cannabinus* (L.) J.D. Sauer	Tidalmarsh amaranth	---	---	---	X	X	X
1	API AME	*Apios americana* Medik.	Groundnut	X	---	X	---	---	---
1	AST ELL	*Aster elliottii* Torr. & A. Gray	Elliott's aster	X	X	X	X	X	X
1	AST TEN	*Aster tenuifolius* L.	Perennial saltmarsh aster	---	---	---	X	X	X
1	BID LAE	*Bidens laevis* (L.) Britton et al.	Smooth beggarticks	X	X	X	---	---	---
1	BID MIT	*Bidens mitis* (Michx.) Sherff	Smallfruit beggarticks	X	X	X	X	X	X
1	CAL SEP	*Calystegia sepium* (L.) R. Br.	Hedge false bindweed	---	---	X	---	X	---
1	CAR ALA	*Carex alata* Torr.	Broadwing sedge	---	---	X	X	X	---
1	CAR COM	*Carex comosa* Boott	Longhair sedge	---	X	X	X	X	X
1	CAR LON	*Carex longii* Mack.	Long's sedge	---	---	---	---	X	X
1	CAR SP1	*Carex* species 1	Sedge	---	---	---	---	X	---
1	CIC MAC	*Cicuta maculata* L.	Spotted water hemlock	X	---	X	---	X	---
1	CYP HAS	*Cyperus haspan* L.	Haspan flatsedge	X	X	X	X	---	X
1	CYP LAN	*Cyperus lanceolatus* Poir.	Epiphytic flatsedge	---	---	---	---	---	X
1	CYP STE	*Cyperus stenolepis* Torr.	Flatsedge	X	X	---	---	---	X
1	CYP VIR	*Cyperus virens* Michx.	Green flatsedge	---	X	---	---	---	---
1	ELE FAL	*Eleocharis fallax* Weath.	Creeping spikerush	X	X	X	X	X	X
1	ELE QUA	*Eleocharis quadrangulata* (Michx.) Roem. & Schult.	Squarestem spikerush	X	X	X	X	X	X
1	GAL OBT	*Galium obtusum* Bigelow subsp. *filifolium* (Wiegand) Puff.	Bluntleaf bedstraw	---	---	X	X	X	X
1	HYD UMB	*Hydrocotyle umbellata* L.	Manyflower marshpennywort	X	X	X	X	X	X
1	IRI VIR	*Iris virginica* L.	Virginia iris	X	X	X	X	X	X
1	JUN ELL	*Juncus elliottii* Chapm.	Bog rush	---	---	X	X	X	---
1	LEE SP.	*Leersia* sp.	Cutgrass	X	X	X	X	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
1	LIL CHI	*Lilaeopsis chinensis* (L.) Kuntze	Eastern grasswort	---	---	---	X	X	X
1	LOB GLA	*Lobelia glandulosa* A. Gray	Coastal plain lobelia	X	X	---	---	---	X
1	LUD DEC	*Ludwigia decurrens* Walter	Wingleaf primrosewillow	X	X	X	X	X	X
1	LUD LEP	*Ludwigia leptocarpa* (Nutt.) H. Hara	Anglestem primrosewillow	X	X	X	X	---	X
1	LUD PIL	*Ludwigia pilosa* Walter	Hairy primrosewillow	---	---	---	---	X	---
1	LYC RUB	*Lycopus rubellus* Moench	Water hoarhound	---	X	---	---	X	X
1	MIK SCA	Mikania scandens (L. f.) Willd.	Climbing hempweed	X	X	X	---	X	X
1	MUR KEI	Murdannia keisak (Hassk.) Hand.-Mazz.	Marsh dewflower	X	X	X	---	X	X
1	NYS BIF	Nyssa sylvatica Marsh. var. biflora (Walt.) Sarg.	Swamp blackgum	---	---	X	X	X	---
1	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	X	X	X	X	X	X
1	POL ARI	Polygonum arifolium L.	Halberd-leaved tear-thumb	X	X	X	X	X	X
1	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	X	X	X
1	POL SAG	Polygonum sagittatum L.	Tear-thumb	X	X	---	---	---	---
1	PON COR	Pontederia cordata L.	Pickerelweed	X	X	X	---	---	---
1	PTI CAP	Ptilimnium capillaceum (Michx.) Raf.	Mock bishop's-weed	---	---	---	---	X	---
1	RHY COR	Rhynchospora corniculata (Lam.) A. Gray	Short-bristle beaksedge	X	---	---	---	---	---
1	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	X	X	X	---	X	X
1	SCI ROB	Scirpus robustus Pursh	Saltmarsh bulrush	---	---	X	---	---	---
1	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
1	SES PUN	Sesbania punicea (Cav.) Benth.	Rattlebox	---	X	X	X	X	---
1	TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	X	X	X	X	X	X
1	TYP DOM	Typha domingensis Pers.	Southern cattail	---	---	X	X	X	X
1	XYR IRI	Xyris iridifolia Chapm.	Irisleaf yelloweyed grass	X	X	X	X	---	X
1	ZIZ AQU	Zizania aquatica L.	Annual wild rice	X	X	---	X	X	X
1	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southern wild rice	X	X	X	X	X	X
2	AST TEN	Aster tenuifolius L.	Perennial saltmarsh aster	X	X	X	X	X	X
2	LIL CHI	Lilaeopsis chinensis (L.) Kuntze	Eastern grasswort	---	---	X	---	---	---

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
2	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	X	---	---	---	---	---
2	SCI ROB	Scirpus robustus Pursh	Saltmarsh bulrush	X	X	X	X	X	X
2	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
2	SPA ALT	Spartina alterniflora (Loisel) var. glabra (Muhl. ex Elliott) Fernald	Saltmarsh cordgrass	X	X	X	X	X	X
2	SPA CYN	Spartina cynosuroides (L.) Roth	Big cordgrass	X	X	X	X	X	X
2	TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	X	X	X	X	X	X
3	ALT PHI	Alternanthera philoxeroides (Mart.) Griseb	Alligatorweed	---	X	X	X	X	X
3	AMA CAN	Amaranthus cannabinus (L.) J.D. Sauer	Tidalmarsh amaranth	X	X	X	X	X	X
3	API AME	Apios americana Medik.	Groundnut	X	---	---	---	---	---
3	AST ELL	Aster elliottii Torr. & A. Gray	Elliott's aster	---	X	X	X	X	X
3	AST TEN	Aster tenuifolius L.	Perennial saltmarsh aster	---	X	---	X	X	X
3	BID LAE	Bidens laevis (L.) Britton et al.	Smooth beggarticks	X	X	X	X	X	X
3	BOL AST	Boltonia asteroides (L.) L'Her.	White doll's-daisy	X	X	X	X	X	---
3	CIC MAC	Cicuta maculata L.	Spotted water hemlock	---	X	X	---	---	---
3	CYP HAS	Cyperus haspan L.	Haspan flatsedge	X	---	---	---	---	---
3	ELE CEL	Eleocharis cellulosa Torr.	Gulf coast spikerush	X	X	---	---	---	---
3	ELE FAL	Eleocharis fallax Weath.	Creeping spikerush	X	X	X	---	X	X
3	JUN ELL	Juncus elliottii Chapm.	Bog rush	---	---	X	---	X	---
3	LEE SP.	Leersia sp.	Cutgrass	X	---	---	---	---	---
3	LIL CHI	Lilaeopsis chinensis (L.) Kuntze	Eastern grasswort	X	X	X	X	X	X
3	LUD PAL	Ludwigia palustris (L.) Elliott	Marsh seedbox	---	---	X	---	---	---
3	OXY FIL	Oxypolis filiformis (Walt.) Britt.	Water dropwort	X	---	---	---	---	---
3	PEL VIR	Peltandra virginica (L.) Schott & Endl.	Green arrow arum	X	---	X	---	X	X
3	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	X	X	X	X	X	X
3	PLU ROS	Pluchea rosea Godfrey	Godfrey's marsh fleabane	X	---	---	---	---	---
3	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	X	X	X
3	PON COR	Pontederia cordata L.	Pickerelweed	X	X	X	---	X	---
3	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	X	X	X	X	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
3	SCI PUN	Scirpus pungens Pers.	Threesquare bulrush	X	X	X	X	X	X
3	SCI ROB	Scirpus robustus Pursh	Saltmarsh bulrush	---	X	X	X	X	---
3	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
3	SIU SUA	Sium suave Walter	Hemlock waterparsnip	---	---	X	---	X	---
3	SPA ALT	Spartina alterniflora (Loisel) var. glabra (Muhl. ex Elliott) Fernald	Saltmarsh cordgrass	X	X	X	X	X	X
3	SPA CYN	Spartina cynosuroides (L.) Roth	Big cordgrass	X	X	X	X	X	X
3	TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	X	---	X	---	---	---
3	ZIZ AQU	Zizania aquatica L.	Annual wild rice	---	X	X	X	---	---
3	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southern wild rice	X	X	X	X	X	X
4	AGA PUR	Agalinis purpurea (L.) Pennell	Gerardia	---	---	---	---	X	---
4	ALT PHI	Alternanthera philoxeroides (Mart.) Griseb	Alligatorweed	---	---	X	---	X	X
4	AMA CAN	Amaranthus cannabinus (L.) J.D. Sauer	Tidalmarsh amaranth	X	X	X	---	X	X
4	AST ELL	Aster elliottii Torr. & A. Gray	Elliott's aster	X	X	X	X	X	X
4	AST NOV	Aster novi-belgii L.	New York aster	---	---	X	---	---	---
4	AST TEN	Aster tenuifolius L.	Perennial saltmarsh aster	X	---	---	---	X	X
4	BID LAE	Bidens laevis (L.) Britton et al.	Smooth beggarticks	X	X	X	X	X	X
4	BID MIT	Bidens mitis (Michx.) Sherff	Smallfruit beggarticks	---	---	---	---	X	---
4	BOL AST	Boltonia asteroides (L.) L'Her.	White doll's-daisy	---	X	---	---	X	---
4	CIC MAC	Cicuta maculata L.	Spotted water hemlock	X	---	X	---	X	---
4	CYP HAS	Cyperus haspan L.	Haspan flatsedge	X	X	---	---	X	X
4	CYP STE	Cyperus stenolepis Torr.	Flatsedge	X	---	---	---	---	X
4	ELE CEL	Eleocharis cellulosa Torr.	Gulf coast spikerush	X	---	---	---	---	---
4	ELE FAL	Eleocharis fallax Weath.	Creeping spikerush	X	X	X	X	X	X
4	ELE QUA	Eleocharis quadrangulata (Michx.) Roem. & Schult.	Squarestem spikerush	X	---	---	---	X	---
4	ELE VIV	Eleocharis vivipara Link	Viviparous spikerush	---	---	X	---	---	---
4	ERE HIE	Erechtites hieracifolia (L.) Raf.	Fireweed	---	---	---	---	X	---
4	ERY AQU	Eryngium aquaticum L.	Rattlesnakemaster	---	---	---	---	X	---

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
4	GAL OBT	Galium obtusum Bigelow subsp. filifolium (Wiegand) Puff.	Bluntleaf bedstraw	---	---	X	---	---	---
4	IRI VIR	Iris virginica L.	Virginia iris	---	---	X	---	X	---
4	JUN ELL	Juncus elliottii Chapm.	Bog rush	---	---	X	---	X	---
4	JUN POL	Juncus polycephalus Michx.	Many-head rush	---	---	X	---	---	---
4	LIL CHI	Lilaeopsis chinensis (L.) Kuntze	Eastern grasswort	---	---	X	---	X	X
4	LUD PAL	Ludwigia palustris (L.) Elliott	Marsh seedbox	---	---	X	---	X	---
4	PAN HEM	Panicum hemitomon Schult.	Maidencane	X	X	X	X	X	X
4	PEL VIR	Peltandra virginica (L.) Schott & Endl.	Green arrow arum	---	---	---	---	X	---
4	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	X	---	---	---	X	X
4	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	X	X	X
4	PON COR	Pontederia cordata L.	Pickerelweed	X	X	X	---	X	---
4	PTI CAP	Ptilimnium capillaceum (Michx.) Raf.	Mock bishop's-weed	---	---	X	---	X	---
4	RHY COR	Rhynchospora corniculata (Lam.) A. Gray	Short-bristle beaksedge	---	---	---	---	---	X
4	RUM VER	Rumex verticillatus L.	Swamp dock	---	---	X	---	X	X
4	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	X	---	X	---	X	---
4	SCI ROB	Scirpus robustus Pursh	Saltmarsh bulrush	---	X	X	X	X	X
4	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
4	SES PUN	Sesbania punicea (Cav.) Benth.	Rattlebox	---	---	X	---	---	---
4	SPA ALT	Spartina alterniflora (Loisel) var. glabra (Muhl. ex Elliott) Fernald	Saltmarsh cordgrass	---	---	---	X	---	---
4	SPA CYN	Spartina cynosuroides (L.) Roth	Big cordgrass	X	X	---	X	X	X
4	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southern wild rice	X	X	X	X	X	X
5	AGA PUR	Agalinis purpurea (L.) Pennell	Gerardia	---	---	X	---	X	---
5	ALT PHI	Alternanthera philoxeroides (Mart.) Griseb	Alligatorweed	X	X	X	X	X	X
5	AMA CAN	Amaranthus cannabinus (L.) J.D. Sauer	Tidalmarsh amaranth	X	---	---	---	X	X
5	AMP ARB	Ampelopsis arborea (L.) Koehne	Peppervine	---	X	X	---	X	---
5	AST ELL	Aster elliottii Torr. & A. Gray	Elliott's aster	X	X	X	X	X	X
5	AST NOV	Aster novi-belgii L.	New York aster	---	X	---	---	---	---

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
5	AST TEN	Aster tenuifolius L.	Perennial saltmarsh aster	X	X	X	X	X	X
5	BAC HAL	Baccharis halimifolia L.	Sea myrtle	X	X	X	X	X	X
5	BID LAE	Bidens laevis (L.) Britton et al.	Smooth beggarticks	X	X	X	X	X	X
5	BID MIT	Bidens mitis (Michx.) Sherff	Smallfruit beggarticks	---	---	---	---	X	---
5	BOL AST	Boltonia asteroides (L.) L'Her.	White doll's-daisy	---	---	---	X	---	---
5	CAL SEP	Calystegia sepium (L.) R. Br.	Hedge false bindweed	---	---	---	---	X	---
5	CIC MAC	Cicuta maculata L.	Spotted water hemlock	X	---	X	---	X	---
5	CYP HAS	Cyperus haspan L.	Haspan flatsedge	X	X	---	---	X	---
5	CYP VIR	Cyperus virens Michx.	Green flatsedge	---	---	X	---	---	---
5	ELE FAL	Eleocharis fallax Weath.	Creeping spikerush	X	X	X	X	X	X
5	ERY AQU	Eryngium aquaticum L.	Rattlesnakemaster	---	---	---	---	X	---
5	EUT CAR	Euthamia caroliniana (L.) Greene ex Porter & Britton	Slender goldenrod	X	X	X	X	---	X
5	HYD UMB	Hydrocotyle umbellata L.	Manyflower marshpennywort	X	X	X	---	X	---
5	JUN EFF	Juncus effusus L.	Soft rush	X	X	X	---	X	---
5	JUN ELL	Juncus elliottii Chapm.	Bog rush	---	---	X	---	X	---
5	JUN MAR	Juncus marginatus Rostk.	Grassleaf rush	---	---	X	---	---	---
5	LIL CHI	Lilaeopsis chinensis (L.) Kuntze	Eastern grasswort	X	X	X	---	X	X
5	LUD PIL	Ludwigia pilosa Walter	Hairy primrosewillow	---	X	---	---	---	---
5	PAN DIC	Panicum dichotomiflorum Michx.	Fall panicum	---	---	---	X	---	---
5	PHY AME	Phytolacca americana L.	American pokeweed	---	---	X	---	---	---
5	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	X	X	X	X	X	X
5	PLU ROS	Pluchea rosea Godfrey	Godfrey's marsh fleabane	X	---	---	---	---	---
5	POL ARI	Polygonum arifolium L.	Halberd-leaved tear-thumb	X	X	---	X	---	---
5	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	---	X	---
5	RUM VER	Rumex verticillatus L.	Swamp dock	---	X	X	---	X	---
5	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	X	X	X	X	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
5	SAU CER	Saururus cernuus L.	Lizard's tail	---	---	X	---	X	---
5	SCI ROB	Scirpus robustus Pursh	Saltmarsh bulrush	---	---	X	---	X	X
5	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
5	SOL SEM	Solidago sempervirens L.	Seaside goldenrod	---	---	---	X	X	X
5	SPA ALT	Spartina alterniflora (Loisel) var. glabra (Muhl. ex Elliott) Fernald	Saltmarsh cordgrass	X	X	X	X	X	X
5	TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	X	X	X	X	X	X
5	ZIZ AQU	Zizania aquatica L.	Annual wild rice	X	X	---	X	X	X
5	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southern wild rice	X	X	X	X	X	X
6	ACE RUB	Acer rubrum L.	Red maple	X	X	X	X	X	X
6	AND GLO	Andropogon glomeratus (Walt.) BSP var. glomeratus	Bushy bluestem	X	X	---	X	---	X
6	AST ELL	Aster elliottii Torr. & A. Gray	Elliott's aster	X	X	X	X	X	X
6	BAC HAL	Baccharis halimifolia L.	Sea myrtle	X	X	X	X	X	X
6	BID LAE	Bidens laevis (L.) Britton et al.	Smooth beggarticks	X	---	X	---	---	X
6	BOL AST	Boltonia asteroides (L.) L'Her.	White doll's-daisy	---	---	---	---	X	---
6	CAL SEP	Calystegia sepium (L.) R. Br.	Hedge false bindweed	X	---	---	---	X	---
6	CAR ALA	Carex alata Torr.	Broadwing sedge	---	---	---	X	---	---
6	CAR COM	Carex comosa Boott	Longhair sedge	---	---	---	---	X	---
6	CAR LON	Carex longii Mack.	Long's sedge	X	---	X	---	---	---
6	CAR SP1	Carex species 1	Sedge	---	---	X	---	X	---
6	CAR SP2	Carex species 2	Sedge	---	---	X	---	---	---
6	CIC MAC	Cicuta maculata L.	Spotted water hemlock	X	---	X	---	X	X
6	CIN ARU	Cinna arundinacea L.	Wood reed	X	---	---	---	---	---
6	CYP HAS	Cyperus haspan L.	Haspan flatsedge	X	X	X	X	X	X
6	CYP STE	Cyperus stenolepis Torr.	Flatsedge	X	---	---	---	---	X
6	ECH CRU	Echinochloa crusgalli (L.) P. Beauv.	Barnyardgrass	---	---	---	X	---	---
6	ELE CEL	Eleocharis cellulosa Torr.	Gulf coast spikerush	X	X	---	---	---	---
6	ELE FAL	Eleocharis fallax Weath.	Creeping spikerush	X	X	X	X	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
6	ELE QUA	Eleocharis quadrangulata (Michx.) Roem. & Schult.	Squarestem spikerush	X	---	X	X	---	---
6	ELE VIV	Eleocharis vivipara Link	Viviparous spikerush	---	---	X	X	---	X
6	EUP LEP	Eupatorium leptophyllum DC.	Falsefennel	X	---	---	---	---	---
6	FUI BRE	Fuirena breviseta (Cov.) Cov.	Umbrellagrass	---	---	---	---	---	X
6	GAL OBT	Galium obtusum Bigelow subsp. filifolium (Wiegand) Puff.	Bluntleaf bedstraw	---	---	X	---	---	---
6	HYD UMB	Hydrocotyle umbellata L.	Manyflower marshpennywort	X	X	X	X	X	X
6	HYP HYP	Hypericum hypericoides (L.) Crantz	St. Andrew's-cross	X	---	---	---	---	---
6	HYP MUT	Hypericum mutilum L.	Dwarf St.-John's-wort	X	---	---	---	---	---
6	IRI VIR	Iris virginica L.	Virginia iris	X	X	X	X	X	X
6	JUN EFF	Juncus effusus L.	Soft rush	X	X	X	X	X	X
6	JUN ELL	Juncus elliottii Chapm.	Bog rush	X	X	X	X	X	X
6	JUN MAR	Juncus marginatus Rostk.	Grassleaf rush	---	---	X	---	X	X
6	JUN MEG	Juncus megacephalus M.A. Curtis	Big-head rush	---	---	---	X	---	X
6	JUN SCI	Juncus scirpoides Lam.	Needle-pod rush	---	---	X	---	---	---
6	KOS VIR	Kosteletzkya virginica (L.) C. Presl. ex A. Gray	Virginia saltmarsh mallow	X	---	---	---	---	---
6	LEE SP.	Leersia sp.	Cutgrass	X	X	X	X	X	X
6	LIL CHI	Lilaeopsis chinensis (L.) Kuntze	Eastern grasswort	---	---	X	X	X	X
6	LUD PAL	Ludwigia palustris (L.) Elliott	Marsh seedbox	---	X	X	---	X	---
6	LUZ FLU	Luziola fluitans (Michx.) Terrell & H. Rob.	Southern watergrass	X	X	X	X	---	---
6	LYC RUB	Lycopus rubellus Moench	Water hoarhound	---	---	X	---	---	---
6	MIK SCA	Mikania scandens (L. f.) Willd.	Climbing hempweed	X	X	X	X	X	X
6	MIM QUA	Mimosa quadrivalvis L.	Sensitive brier	---	---	X	---	---	---
6	MUR KEI	Murdannia keisak (Hassk.) Hand.-Mazz.	Marsh dewflower	X	---	X	X	X	---
6	MYR CER	Myrica cerifera L.	Wax myrtle	X	X	X	X	X	X
6	OSM REG	Osmunda regalis L.	Royal fern	X	X	X	X	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
6	PAN DIC	Panicum dichotomiflorum Michx.	Fall panicum	---	---	X	---	---	---
6	PAN RIG	Panicum rigidulum Nees	Redtop panicum	X	X	---	X	---	X
6	PAS URV	Paspalum urvillei Steud.	Vaseygrass	---	---	---	X	X	X
6	PER PAL	Persea palustris (Raf.) Sarg.	Swampbay	X	X	---	X	---	X
6	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	X	X	X	X	X	X
6	POL ARI	Polygonum arifolium L.	Halberd-leaved tear-thumb	---	---	X	X	X	X
6	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	X	X	X
6	PON COR	Pontederia cordata L.	Pickerelweed	---	---	X	---	X	---
6	PTI CAP	Ptilimnium capillaceum (Michx.) Raf.	Mock bishop's-weed	---	---	---	---	X	---
6	PTI COS	Ptilimnium costatum (Ell.) Raf.	Bishop's-weed	---	---	X	---	---	---
6	QUE LAU	Quercus laurifolia Michx.	Swamp laurel oak	---	---	X	X	X	X
6	RHY MCC	Rhynchospora microcarpa Baldwin ex A. Gray	Southern beaksedge	X	---	---	---	---	---
6	RUM VER	Rumex verticillatus L.	Swamp dock	---	---	X	---	---	---
6	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	X	X	X	---	X	---
6	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
6	SOL SEM	Solidago sempervirens L.	Seaside goldenrod	X	X	---	X	X	X
6	TAX DIS	Taxodium distichum (L.) Rich.	Bald cypress	X	X	---	---	---	X
6	TOX RAD	Toxicodendron radicans (L.) Kuntze	Poison ivy	---	---	X	---	X	X
6	TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	X	X	X	X	X	X
6	UNK GRA	Unknown grass	---	---	---	---	---	X	---
6	VIG LUT	Vigna luteola (Jacq.) Benth.	Hairypod cowpea	---	---	X	---	---	---
6	XYR IRI	Xyris iridifolia Chapm.	Irisleaf yelloweyed grass	X	X	---	---	---	---
6	ZIZ AQU	Zizania aquatica L.	Annual wild rice	X	X	---	X	---	X
6	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southern wild rice	X	X	X	X	X	X
7	ALT PHI	Alternanthera philoxeroides (Mart.) Griseb	Alligatorweed	---	X	X	X	X	X
7	AMA CAN	Amaranthus cannabinus (L.) J.D. Sauer	Tidalmarsh amaranth	X	X	X	X	X	X
7	AST ELL	Aster elliottii Torr. & A. Gray	Elliott's aster	X	X	X	X	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
7	AST NOV	Aster novi-belgii L.	New York aster	X	X	X	---	X	---
7	AST TEN	Aster tenuifolius L.	Perennial saltmarsh aster	---	---	---	X	X	X
7	BID LAE	Bidens laevis (L.) Britton et al.	Smooth beggarticks	X	X	X	X	X	X
7	BOL AST	Boltonia asteroides (L.) L'Her.	White doll's-daisy	X	X	X	X	X	X
7	CIC MAC	Cicuta maculata L.	Spotted water hemlock	X	---	X	---	X	---
7	ELE CEL	Eleocharis cellulosa Torr.	Gulf coast spikerush	X	---	---	---	---	---
7	ELE FAL	Eleocharis fallax Weath.	Creeping spikerush	---	X	X	X	X	---
7	LIL CHI	Lilaeopsis chinensis (L.) Kuntze	Eastern grasswort	X	X	X	X	X	---
7	PEL VIR	Peltandra virginica (L.) Schott & Endl.	Green arrow arum	X	X	X	X	X	X
7	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	---	X	---	X	X	X
7	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	X	X	X
7	PON COR	Pontederia cordata L.	Pickerelweed	---	X	---	---	---	X
7	PTI COS	Ptilimnium costatum (Ell.) Raf.	Bishop's-weed	X	X	---	---	---	---
7	RUM VER	Rumex verticillatus L.	Swamp dock	---	---	X	---	---	---
7	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	X	X	X	---	X	---
7	SCI ROB	Scirpus robustus Pursh	Saltmarsh bulrush	X	X	X	X	X	X
7	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
7	SIU SUA	Sium suave Walter	Hemlock waterparsnip	---	---	X	---	X	---
7	SPA ALT	Spartina alterniflora (Loisel) var. glabra (Muhl. ex Elliott) Fernald	Saltmarsh cordgrass	X	X	X	X	X	X
7	SPA CYN	Spartina cynosuroides (L.) Roth	Big cordgrass	X	X	X	X	X	X
7	TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	X	X	X	X	X	X
7	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southern wild rice	X	X	X	X	X	X
8	ACE RUB	Acer rubrum L.	Red maple	---	X	---	---	---	---
8	AGA PUR	Agalinis purpurea (L.) Pennell	Gerardia	X	X	X	X	X	X
8	AGR PER	Agrostis perennans (Walter) Tuck.	Autumn bentgrass	---	---	---	---	---	X
8	ALN SER	Alnus serrulata (Aiton) Willd.	Hazel alder	X	X	X	X	X	X
8	AMA CAN	Amaranthus cannabinus (L.) J.D. Sauer	Tidalmarsh amaranth	---	X	X	---	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
8	AND GLO	Andropogon glomeratus (Walt.) BSP var. glomeratus	Bushy bluestem	---	---	---	X	---	---
8	API AME	Apios americana Medik.	Groundnut	X	---	X	X	X	---
8	ART HIS	Arthraxon hispidus (Thunb.) Makino	Small carpgrass	X	X	X	X	X	X
8	AST ELL	Aster elliottii Torr. & A. Gray	Elliott's aster	X	X	X	X	X	X
8	AST NOV	Aster novi-belgii L.	New York aster	X	---	---	X	---	---
8	AST SUB	Aster subulatus Michx.	Annual saltmarsh aster	X	---	---	---	---	---
8	BAC HAL	Baccharis halimifolia L.	Sea myrtle	X	---	X	X	---	X
8	BID LAE	Bidens laevis (L.) Britton et al.	Smooth beggarticks	X	X	X	X	X	X
8	BID MIT	Bidens mitis (Michx.) Sherff	Smallfruit beggarticks	---	---	X	X	X	X
8	BOE CYL	Boehmeria cylindrica (L.) Sw.	False nettle	---	---	X	---	---	---
8	BOL AST	Boltonia asteroides (L.) L'Her.	White doll's-daisy	X	---	---	---	---	X
8	CAL SEP	Calystegia sepium (L.) R. Br.	Hedge false bindweed	X	---	---	---	---	---
8	CAR ALA	Carex alata Torr.	Broadwing sedge	---	---	---	X	X	---
8	CAR COM	Carex comosa Boott	Longhair sedge	---	---	X	X	X	X
8	CAR LON	Carex longii Mack.	Long's sedge	---	X	X	---	X	X
8	CAR LUP	Carex lupuliformis Sartwell ex Dewey	False hop sedge	---	---	---	---	X	X
8	CAR SP1	Carex species 1	Sedge	---	---	---	X	---	---
8	CHA FAS	Chamaecrista fasciculata (Michx.) Greene	Partridge-pea	X	X	X	X	X	X
8	CIC MAC	Cicuta maculata L.	Spotted water hemlock	X	X	X	X	X	X
8	CLE CRI	Clematis crispa L.	Swamp leather-flower	---	---	X	---	X	---
8	CYP HAS	Cyperus haspan L.	Haspan flatsedge	X	X	X	X	X	X
8	CYP LAN	Cyperus lanceolatus Poir.	Epiphytic flatsedge	X	X	---	X	---	X
8	CYP STE	Cyperus stenolepis Torr.	Flatsedge	X	---	---	X	---	X
8	CYP VIR	Cyperus virens Michx.	Green flatsedge	---	---	---	---	---	X
8	DUL ARU	Dulichium arundinaceum (L.) Britton	Threeway sedge	X	X	X	X	X	X
8	ELE CEL	Eleocharis cellulosa Torr.	Gulf coast spikerush	X	X	X	X	---	---
8	ELE FAL	Eleocharis fallax Weath.	Creeping spikerush	X	X	X	X	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
8	ELE QUA	Eleocharis quadrangulata (Michx.) Roem. & Schult.	Squarestem spikerush	---	X	X	---	X	X
8	ERA ELL	Eragrostis elliottii S. Wats.	Elliott lovegrass	X	---	---	X	---	---
8	ERY AQU	Eryngium aquaticum L.	Rattlesnakemaster	---	---	X	---	---	---
8	FUI BRE	Fuirena breviseta (Cov.) Cov.	Umbrellagrass	X	X	X	X	X	X
8	GAL OBT	Galium obtusum Bigelow subsp. filifolium (Wiegand) Puff.	Bluntleaf bedstraw	X	X	X	X	X	X
8	HAB REP	Habenaria repens Nutt.	Waterspider false reinorchid	---	---	X	X	---	X
8	HAM VIR	Hamamelis virginiana L.	American witchhazel	---	---	---	---	---	X
8	HYD UMB	Hydrocotyle umbellata L.	Manyflower marshpennywort	---	---	---	---	X	X
8	HYP MUT	Hypericum mutilum L.	Dwarf St.-John's-wort	X	X	X	---	X	X
8	HYP SP.	Hypericum sp.	St. John's-wort	---	---	---	---	---	X
8	IRI VIR	Iris virginica L.	Virginia iris	X	X	X	X	X	X
8	JUN EFF	Juncus effusus L.	Soft rush	---	---	---	---	X	X
8	JUN ELL	Juncus elliottii Chapm.	Bog rush	X	X	X	---	X	X
8	JUN MAR	Juncus marginatus Rostk.	Grassleaf rush	---	X	X	X	X	X
8	JUN MEG	Juncus megacephalus M.A. Curtis	Big-head rush	---	---	---	X	---	X
8	JUN POL	Juncus polycephalus Michx.	Many-head rush	---	---	---	---	X	---
8	JUN SCI	Juncus scirpoides Lam.	Needle-pod rush	---	---	---	---	---	X
8	LEE SP.	Leersia sp.	Cutgrass	X	X	X	X	X	X
8	LOB CAR	Lobelia cardinalis L.	Cardinalflower	---	---	---	X	---	---
8	LOB GLA	Lobelia glandulosa A. Gray	Coastal plain lobelia	X	---	X	X	---	X
8	LON JAP	Lonicera japonica Thunb.	Japanese honeysuckle	---	---	---	---	X	X
8	LUD DEC	Ludwigia decurrens Walter	Wingleaf primrosewillow	X	X	---	X	---	---
8	LUD LEP	Ludwigia leptocarpa (Nutt.) H. Hara	Anglestem primrosewillow	---	---	X	X	X	X
8	LUD OCT	Ludwigia octovalvis (Jacq.) Raven	Mexican primrosewillow	---	---	---	---	---	X
8	LUD PAL	Ludwigia palustris (L.) Elliott	Marsh seedbox	---	---	---	---	---	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
8	LUD PIL	Ludwigia pilosa Walter	Hairy primrosewillow	---	---	X	X	X	X
8	LUZ FLU	Luziola fluitans (Michx.) Terrell & H. Rob.	Southern watergrass	---	X	X	X	X	X
8	LYC RUB	Lycopus rubellus Moench	Water hoarhound	X	X	X	X	X	X
8	MIK SCA	Mikania scandens (L. f.) Willd.	Climbing hempweed	X	X	X	X	X	X
8	MUR KEI	Murdannia keisak (Hassk.) Hand.-Mazz.	Marsh dewflower	X	X	X	X	X	X
8	MYR CER	Myrica cerifera L.	Wax myrtle	X	X	X	X	X	X
8	ONO SEN	Onoclea sensibilis L.	Sensitive fern	X	X	X	X	X	X
8	ORO AQU	Orontium aquaticum L.	Goldenclub	---	X	---	---	---	---
8	OSM REG	Osmunda regalis L.	Royal fern	X	X	X	X	X	X
8	PAN HEM	Panicum hemitomon Schult.	Maidencane	X	X	X	X	X	---
8	PAN RIG	Panicum rigidulum Nees	Redtop panicum	X	X	---	X	---	X
8	PER PAL	Persea palustris (Raf.) Sarg.	Swampbay	---	X	---	---	---	---
8	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	X	X	---	---	---	---
8	POL ARI	Polygonum arifolium L.	Halberd-leaved tear-thumb	X	X	X	X	X	X
8	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	X	X	X
8	POL SAG	Polygonum sagittatum L.	Tear-thumb	X	X	X	X	X	X
8	PON COR	Pontederia cordata L.	Pickerelweed	---	---	---	X	X	X
8	PTI CAP	Ptilimnium capillaceum (Michx.) Raf.	Mock bishop's-weed	---	---	X	---	X	---
8	PTI COS	Ptilimnium costatum (Ell.) Raf.	Bishop's-weed	X	X	X	X	X	X
8	RHY COR	Rhynchospora corniculata (Lam.) A. Gray	Short-bristle beaksedge	X	X	---	X	---	X
8	RHY MCC	Rhynchospora microcarpa Baldwin ex A. Gray	Southern beaksedge	---	X	X	X	X	X
8	RHY MIC	Rhynchospora microcephala (Britton) Britton ex Small	Small bunched beaksedge	X	---	X	X	X	X
8	RUM VER	Rumex verticillatus L.	Swamp dock	---	---	---	X	---	X
8	SAC GIG	Saccharum giganteum (Walter) Pers.	Sugarcane plumegrass	X	X	---	X	---	---
8	SAC IND	Sacciolepis indica (L.) Chase	India cupscale	---	X	---	X	X	X
8	SAC STR	Sacciolepis striata (L.) Nash	American cupscale	X	X	---	X	---	---

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
8	SAG FIL	Sagittaria filiformis J.G. Sm.	Arrowhead	X	X	---	---	---	---
8	SAG GRA	Sagittaria graminea Michx.	Grassy arrowhead	---	---	---	---	---	X
8	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	X	X	X	X	X	X
8	SAG LAT	Sagittaria latifolia Willd.	Common arrowhead	X	X	X	X	X	X
8	SAL CAR	Salix caroliniana Michx.	Carolina willow	---	---	---	---	X	---
8	SCI CYP	Scirpus cyperinus (L.) Kunth	Woolgrass	X	---	---	---	---	---
8	SCI PUN	Scirpus pungens Pers.	Threesquare bulrush	---	---	---	---	---	X
8	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
8	SIU SUA	Sium suave Walter	Hemlock waterparsnip	---	---	X	---	---	---
8	SOL SEM	Solidago sempervirens L.	Seaside goldenrod	X	X	---	X	X	X
8	TEU CAN	Teucrium canadense L.	Wood sage	---	X	X	---	X	---
8	TOX RAD	Toxicodendron radicans (L.) Kuntze	Poison ivy	---	X	X	X	X	---
8	TRI WAL	Triadenum walteri (J.F. Gmel.) Gleason	Greater marsh St.-John's-wort	---	---	X	X	X	X
8	TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	X	X	X	X	X	X
8	UNK HER1	Unknown herb 1	---	---	---	---	---	---	X
8	UNK HER2	Unknown herb 2	---	---	---	---	---	---	X
8	UNK HER3	Unknown herb 3	---	---	---	---	---	---	X
8	UNK HER4	Unknown herb 4	---	---	---	---	---	---	X
8	UNK LEG1	Unknown legume 1	---	---	---	---	---	---	X
8	VIB DEN	Viburnum dentatum L.	Southem arrowwood	---	X	X	---	X	---
8	VIB NUD	Viburnum nudum L.	Possumhaw	X	---	---	---	---	---
8	VIG LUT	Vigna luteola (Jacq.) Benth.	Hairypod cowpea	---	---	X	X	X	X
8	VIO PRI	Viola primulifolia L.	Primroseleaf violet	X	X	X	X	X	X
8	XYR IRI	Xyris iridifolia Chapm.	Irisleaf yelloweyed grass	X	X	X	X	---	X
8	ZIZ AQU	Zizania aquatica L.	Annual wild rice	---	---	---	---	X	---
8	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southern wild rice	X	X	X	X	X	X
9	ACE RUB	Acer rubrum L.	Red maple	X	X	---	---	X	---
9	AGA PUR	Agalinis purpurea (L.) Pennell	Gerardia	X	---	---	---	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
9	AMA CAN	Amaranthus cannabinus (L.) J.D. Sauer	Tidalmarsh amaranth	X	---	X	X	X	X
9	AMP ARB	Ampelopsis arborea (L.) Koehne	Peppervine	---	X	X	X	X	X
9	API AME	Apios americana Medik.	Groundnut	---	---	---	---	X	---
9	AST ELL	Aster elliottii Torr. & A. Gray	Elliott's aster	X	X	X	X	X	X
9	AST LAT	Aster lateriflorus (L.) Britton	Calico aster	---	---	---	---	X	---
9	AST NOV	Aster novi-belgii L.	New York aster	X	---	---	---	---	---
9	BAC HAL	Baccharis halimifolia L.	Sea myrtle	X	X	X	X	X	X
9	BID LAE	Bidens laevis (L.) Britton et al.	Smooth beggarticks	X	X	X	X	X	X
9	BID MIT	Bidens mitis (Michx.) Sherff	Smallfruit beggarticks	---	---	---	---	X	X
9	BOE CYL	Boehmeria cylindrica (L.) Sw.	False nettle	---	---	X	X	X	---
9	BOL AST	Boltonia asteroides (L.) L'Her.	White doll's-daisy	---	X	---	X	X	X
9	CAL SEP	Calystegia sepium (L.) R. Br.	Hedge false bindweed	---	---	X	---	X	X
9	CAR LUP	Carex lupuliformis Sartwell ex Dewey	False hop sedge	---	---	X	---	X	---
9	CEL LAE	Celtis laevigata Willd.	Hackberry	---	X	---	---	---	---
9	CEP OCC	Cephalanthus occidentalis L.	Common buttonbush	X	X	X	X	X	X
9	CIC MAC	Cicuta maculata L.	Spotted water hemlock	X	X	X	X	X	X
9	COR FOE	Cornus foemina Mill.	Swamp dogwood	X	X	X	X	X	X
9	CYP HAS	Cyperus haspan L.	Haspan flatsedge	X	---	---	X	X	X
9	CYP VIR	Cyperus virens Michx.	Green flatsedge	---	---	---	X	---	X
9	ELE CEL	Eleocharis cellulosa Torr.	Gulf coast spikerush	---	X	---	---	---	---
9	ELE FAL	Eleocharis fallax Weath.	Creeping spikerush	X	X	X	X	X	X
9	ELE QUA	Eleocharis quadrangulata (Michx.) Roem. & Schult.	Squarestem spikerush	---	---	---	X	X	X
9	GAL OBT	Galium obtusum Bigelow subsp. filifolium (Wiegand) Puff.	Bluntleaf bedstraw	X	---	X	---	X	X
9	HYD UMB	Hydrocotyle umbellata L.	Manyflower marshpennywort	---	X	X	X	X	X
9	ILE VER	Ilex verticillata (L.) A. Gray	Common winterberry	X	---	X	X	X	X
9	IRI VIR	Iris virginica L.	Virginia iris	---	---	X	---	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
g	JUN ELL	Juncus elliottii Chapm.	Bog rush	---	---	---	---	X	---
g	KOS VIR	Kosteletzkya virginica (L.) C. Presl. ex A. Gray	Virginia saltmarsh mallow	---	X	---	X	---	---
g	LEE SP.	Leersia sp.	Cutgrass	---	---	---	---	X	X
g	LOB GLA	Lobelia glandulosa A. Gray	Coastal plain lobelia	---	---	---	---	X	---
g	LON JAP	Lonicera japonica Thunb.	Japanese honeysuckle	X	X	X	---	---	---
g	LUD MIC	Ludwigia microcarpa Michx.	Small-fruit seedbox	X	---	---	---	---	---
g	LUD PAL	Ludwigia palustris (L.) Elliott	Marsh seedbox	---	---	X	X	X	---
g	LUD PIL	Ludwigia pilosa Walter	Hairy primrosewillow	---	X	---	X	X	X
g	LYC RUB	Lycopus rubellus Moench	Water hoarhound	---	---	---	---	X	---
g	MIK SCA	Mikania scandens (L. f.) Willd.	Climbing hempweed	X	X	X	X	X	X
g	MUR KEI	Murdannia keisak (Hassk.) Hand.-Mazz.	Marsh dewflower	X	---	X	X	X	X
g	MYR CER	Myrica cerifera L.	Wax myrtle	X	X	X	X	X	X
g	NYS AQU	Nyssa aquatica L.	Water tupelo	---	X	---	---	---	---
g	NYS BIF	Nyssa sylvatica Marsh. var. biflora (Walt.) Sarg.	Swamp blackgum	---	---	---	---	X	X
g	ONO SEN	Onoclea sensibilis L.	Sensitive fern	X	X	X	X	X	X
g	OSM REG	Osmunda regalis L.	Royal fern	X	X	X	X	X	X
g	PER PAL	Persea palustris (Raf.) Sarg.	Swampbay	X	X	X	X	X	X
g	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	---	---	---	X	X	X
g	POL ARI	Polygonum arifolium L.	Halberd-leaved tear-thumb	X	X	X	X	X	X
g	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	X	X	X
g	POL SAG	Polygonum sagittatum L.	Tear-thumb	---	---	---	X	---	---
g	PON COR	Pontederia cordata L.	Pickerelweed	X	X	X	---	X	---
g	PTI CAP	Ptilimnium capillaceum (Michx.) Raf.	Mock bishop's-weed	---	---	X	---	X	---
g	RHY COR	Rhynchospora corniculata (Lam.) A. Gray	Short-bristle beaksedge	X	---	---	---	---	X
g	ROS PAL	Rosa palustris Marshall	Swamp rose	X	X	X	X	X	X
g	RUB ARG	Rubus argutus Link	Sawtooth blackberry	X	X	X	X	X	X

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
9	RUM VER	Rumex verticillatus L.	Swamp dock	---	---	X	---	X	---
9	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	---	---	X	X	X	---
9	SAL CAR	Salix caroliniana Michx.	Carolina willow	X	X	X	X	X	X
9	SAM CAN	Sambucus canadensis L.	Elderberry	---	---	X	---	---	---
9	SAU CER	Saururus cemuus L.	Lizard's tail	X	---	X	X	X	---
9	SCI CYP	Scirpus cyperinus (L.) Kunth	Woolgrass	X	X	---	---	---	---
9	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
9	TOX RAD	Toxicodendron radicans (L.) Kuntze	Poison ivy	X	---	X	---	---	---
9	TRI WAL	Triadenum walteri (J.F. Gmel.) Gleason	Greater marsh St.-John's-wort	---	---	X	X	X	---
9	VIG LUT	Vigna luteola (Jacq.) Benth.	Hairypod cowpea	---	X	X	X	---	---
9	WIS FRU	Wisteria frutescens (L.) Poir.	American wisteria	X	---	---	X	X	X
9	ZIZ AQU	Zizania aquatica L.	Annual wild rice	X	---	---	---	---	---
9	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southem wild rice	X	X	X	X	X	X
10	ALT PHI	Alternanthera philoxeroides (Mart.) Griseb	Alligatorweed	X	X	X	X	X	X
10	AMA CAN	Amaranthus cannabinus (L.) J.D. Sauer	Tidalmarsh amaranth	X	X	X	X	X	X
10	AST ELL	Aster elliottii Torr. & A. Gray	Elliott's aster	---	X	X	---	---	---
10	AST TEN	Aster tenuifolius L.	Perennial saltmarsh aster	X	X	X	X	X	X
10	BID LAE	Bidens laevis (L.) Britton et al.	Smooth beggarticks	X	X	X	---	---	---
10	CIC MAC	Cicuta maculata L.	Spotted water hemlock	X	---	---	---	---	---
10	ELE FAL	Eleocharis fallax Weath.	Creeping spikerush	X	X	X	X	X	X
10	IRI VIR	Iris virginica L.	Virginia iris	X	X	X	---	---	---
10	LIL CHI	Lilaeopsis chinensis (L.) Kuntze	Eastern grasswort	---	---	X	X	X	X
10	PEL VIR	Peltandra virginica (L.) Schott & Endl.	Green arrow arum	X	X	X	X	X	---
10	PLU ODO	Pluchea odorata (L.) Cass.	Saltmarsh fleabane	X	X	X	X	X	X
10	POL ARI	Polygonum arifolium L.	Halberd-leaved tear-thumb	X	---	---	---	---	---
10	POL PUN	Polygonum punctatum Ell.	Dotted smartweed	X	X	X	---	---	---
10	PON COR	Pontederia cordata L.	Pickerelweed	X	---	---	---	---	---

Table A-1. Continued

Q	Species Code	Scientific Name	Common Name	Sampling Date 10/97	10/99	5/00	10/00	6/01	10/01
10	RUM VER	Rumex verticillatus L.	Swamp dock	---	---	---	---	X	---
10	SAG LAN	Sagittaria lancifolia L.	Bulltongue arrowhead	X	X	X	X	X	X
10	SCI ROB	Scirpus robustus Pursh	Saltmarsh bulrush	X	X	X	X	X	X
10	SCI TAB	Scirpus tabernaemontani C.C. Gmel.	Softstem bulrush	X	X	X	X	X	X
10	SPA ALT	Spartina alterniflora (Loisel) var. glabra (Muhl. ex Elliott) Fernald	Saltmarsh cordgrass	X	X	X	X	X	X
10	TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	X	X	X	X	X	X
10	ZIZ MIL	Zizaniopsis miliacea (Michx.) Doll & Asch.	Southern wild rice	X	X	X	X	X	X

Table A-2. Frequency and percent cover for each species within each belt transect for each of the six vegetation-sampling events.

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
1	Oct-97	AGA PUR	36	1.4	1.1	0.6	13	11	2.0
1	Oct-99	AGA PUR	107	4.2	2.7	1.5	7	8	5.7
1	May-00	AGA PUR	121	3.6	3.4	1.6	9	12	5.2
1	Jun-01	AGA PUR	5	0.2	0.1	0.1	26	27	0.2
1	Oct-01	AGA PUR	2	0.1	0.0	0.0	29	31	0.1
1	Oct-97	ALT PHI	33	1.3	1.4	0.8	15	9	2.1
1	Oct-99	ALT PHI	36	1.4	4.0	2.3	15	6	3.7
1	May-00	ALT PHI	56	1.7	6.4	3.0	15	6	4.7
1	Oct-00	ALT PHI	31	1.4	2.6	1.4	8	7	2.8
1	Jun-01	ALT PHI	44	1.6	6.6	3.9	11	5	5.5
1	Oct-01	ALT PHI	48	2.1	5.3	3.9	9	5	6.0
1	Oct-00	AMA CAN	3	0.1	0.1	0.1	21	21	0.2
1	Jun-01	AMA CAN	15	0.6	0.3	0.2	17	19	0.7
1	Oct-01	AMA CAN	15	0.7	0.5	0.4	17	13	1.0
1	Oct-97	API AME	17	0.7	0.6	0.3	20	17	1.0
1	May-00	API AME	8	0.2	0.2	0.1	27	28	0.3
1	Oct-97	AST ELL	342	13.4	20.6	11.5	3	3	24.8
1	Oct-99	AST ELL	340	13.2	15.3	8.7	3	4	21.9
1	May-00	AST ELL	420	12.5	30.0	14.0	2	2	26.5
1	Oct-00	AST ELL	410	18.6	18.9	10.2	3	4	28.9
1	Jun-01	AST ELL	398	14.8	28.6	16.9	2	2	31.7
1	Oct-01	AST ELL	323	14.1	11.0	8.2	3	3	22.3
1	Oct-00	AST TEN	3	0.1	0.1	0.1	21	21	0.2
1	Jun-01	AST TEN	6	0.2	0.1	0.1	23	26	0.3
1	Oct-01	AST TEN	14	0.6	0.5	0.4	19	13	1.0
1	Oct-97	BID LAE	22	0.9	0.5	0.3	17	19	1.1
1	Oct-99	BID LAE	34	1.3	2.0	1.1	16	11	2.5
1	May-00	BID LAE	10	0.3	0.3	0.1	25	26	0.4
1	Oct-97	BID MIT	27	1.1	0.8	0.4	16	16	1.5
1	Oct-99	BID MIT	67	2.6	2.1	1.2	10	9	3.8
1	May-00	BID MIT	100	3.0	2.7	1.3	11	13	4.3
1	Oct-00	BID MIT	3	0.1	0.0	0.0	21	26	0.1
1	Jun-01	BID MIT	33	1.2	0.5	0.3	12	13	1.5
1	Oct-01	BID MIT	7	0.3	0.1	0.1	25	25	0.4
1	May-00	CAL SEP	3	0.1	0.1	0.0	31	32	0.1
1	Jun-01	CAL SEP	1	0.0	0.0	0.0	34	34	0.0
1	May-00	CAR ALA	26	0.8	0.6	0.3	22	23	1.1
1	Oct-00	CAR ALA	19	0.9	0.2	0.1	10	18	1.0
1	Jun-01	CAR ALA	13	0.5	0.3	0.2	19	20	0.7
1	Oct-99	CAR COM	5	0.2	0.2	0.1	28	27	0.3
1	May-00	CAR COM	41	1.2	1.4	0.7	17	18	1.9
1	Oct-00	CAR COM	8	0.4	0.2	0.1	16	16	0.5
1	Jun-01	CAR COM	1	0.0	0.0	0.0	34	34	0.0
1	Oct-01	CAR COM	7	0.3	0.3	0.2	25	16	0.5
1	Jun-01	CAR LON	14	0.5	0.2	0.1	18	22	0.7
1	Oct-01	CAR LON	39	1.7	0.5	0.4	10	11	2.1

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
1	Jun-01	CAR SP1	1	0.0	0.1	0.1	34	27	0.1
1	Oct-97	CIC MAC	9	0.4	0.3	0.2	23	24	0.5
1	May-00	CIC MAC	27	0.8	0.8	0.4	21	21	1.2
1	Jun-01	CIC MAC	5	0.2	0.2	0.1	26	23	0.3
1	Oct-97	CYP HAS	50	2.0	1.0	0.6	10	13	2.5
1	Oct-99	CYP HAS	56	2.2	1.6	0.9	12	14	3.1
1	May-00	CYP HAS	3	0.1	0.2	0.1	31	28	0.2
1	Oct-00	CYP HAS	11	0.5	0.2	0.1	15	14	0.6
1	Oct-01	CYP HAS	9	0.4	0.1	0.1	23	24	0.5
1	Oct-01	CYP LAN	4	0.2	0.1	0.1	27	26	0.3
1	Oct-97	CYP STE	22	0.9	0.6	0.3	17	17	1.2
1	Oct-99	CYP STE	2	0.1	0.1	0.1	31	30	0.1
1	Oct-01	CYP STE	2	0.1	0.1	0.1	29	27	0.2
1	Oct-99	CYP VIR	25	1.0	0.9	0.5	18	17	1.5
1	Oct-97	ELE FAL	471	18.4	67.6	37.6	1	1	56.0
1	Oct-99	ELE FAL	466	18.1	72.7	41.3	1	1	59.4
1	May-00	ELE FAL	486	14.5	81.0	37.9	1	1	52.4
1	Oct-00	ELE FAL	476	21.6	77.0	41.7	1	1	63.4
1	Jun-01	ELE FAL	475	17.7	77.2	45.5	1	1	63.2
1	Oct-01	ELE FAL	473	20.7	65.4	48.7	1	1	69.4
1	Oct-97	ELE QUA	68	2.7	1.3	0.7	8	10	3.4
1	Oct-99	ELE QUA	84	3.3	2.1	1.2	8	10	4.5
1	May-00	ELE QUA	46	1.4	2.2	1.0	16	15	2.4
1	Oct-00	ELE QUA	14	0.6	1.2	0.7	12	9	1.3
1	Jun-01	ELE QUA	16	0.6	0.5	0.3	16	13	0.9
1	Oct-01	ELE QUA	16	0.7	0.2	0.2	16	20	0.9
1	May-00	GAL OBT	13	0.4	1.3	0.6	23	19	1.0
1	Oct-00	GAL OBT	2	0.1	0.0	0.0	24	24	0.1
1	Jun-01	GAL OBT	6	0.2	0.1	0.1	23	27	0.3
1	Oct-01	GAL OBT	2	0.1	0.0	0.0	29	31	0.1
1	Oct-97	HYD UMB	45	1.8	0.9	0.5	11	15	2.3
1	Oct-99	HYD UMB	31	1.2	0.8	0.5	17	18	1.7
1	May-00	HYD UMB	221	6.6	4.1	1.9	6	10	8.5
1	Oct-00	HYD UMB	12	0.5	0.2	0.1	14	15	0.7
1	Jun-01	HYD UMB	187	7.0	3.0	1.8	6	8	8.7
1	Oct-01	HYD UMB	37	1.6	0.4	0.3	11	15	1.9
1	Oct-97	IRI VIR	6	0.2	0.3	0.2	26	24	0.4
1	Oct-99	IRI VIR	11	0.4	0.3	0.2	23	24	0.6
1	May-00	IRI VIR	59	1.8	1.7	0.8	14	16	2.6
1	Oct-00	IRI VIR	2	0.1	0.0	0.0	24	24	0.1
1	Jun-01	IRI VIR	32	1.2	0.9	0.5	13	12	1.7
1	Oct-01	IRI VIR	21	0.9	0.2	0.1	13	22	1.1
1	May-00	JUN ELL	36	1.1	0.8	0.4	19	22	1.4
1	Oct-00	JUN ELL	4	0.2	0.1	0.1	20	19	0.2
1	Jun-01	JUN ELL	8	0.3	0.2	0.1	22	23	0.4
1	Oct-97	LEE SP.	221	8.6	20.0	11.1	5	4	19.7
1	Oct-99	LEE SP.	218	8.5	20.6	11.7	4	3	20.2

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
1	May-00	LEE SP.	285	8.5	15.6	7.3	5	4	15.8
1	Oct-00	LEE SP.	295	13.4	24.6	13.3	4	3	26.7
1	Jun-01	LEE SP.	197	7.3	6.6	3.9	5	6	11.2
1	Oct-01	LEE SP.	154	6.7	5.6	4.2	5	4	10.9
1	Oct-00	LIL CHI	1	0.0	0.1	0.1	28	21	0.1
1	Jun-01	LIL CHI	5	0.2	0.4	0.2	26	18	0.4
1	Oct-01	LIL CHI	2	0.1	0.1	0.1	29	27	0.2
1	Oct-97	LOB GLA	2	0.1	0.1	0.1	30	28	0.1
1	Oct-99	LOB GLA	3	0.1	0.1	0.1	30	30	0.2
1	Oct-01	LOB GLA	1	0.0	0.0	0.0	33	31	0.1
1	Oct-97	LUD DEC	6	0.2	0.1	0.1	26	28	0.3
1	Oct-99	LUD DEC	50	1.9	1.6	0.9	13	15	2.9
1	May-00	LUD DEC	39	1.2	1.5	0.7	18	17	1.9
1	Oct-00	LUD DEC	14	0.6	0.3	0.2	12	11	0.8
1	Jun-01	LUD DEC	26	1.0	0.5	0.3	14	13	1.3
1	Oct-01	LUD DEC	20	0.9	0.5	0.4	14	12	1.3
1	Oct-97	LUD LEP	111	4.3	3.1	1.7	7	7	6.1
1	Oct-99	LUD LEP	71	2.8	1.8	1.0	9	13	3.8
1	May-00	LUD LEP	160	4.8	5.1	2.4	7	8	7.2
1	Oct-00	LUD LEP	2	0.1	0.0	0.0	24	26	0.1
1	Oct-01	LUD LEP	67	2.9	1.3	1.0	8	9	3.9
1	Jun-01	LUD PIL	91	3.4	2.1	1.2	9	11	4.6
1	Oct-99	LYC RUB	11	0.4	0.5	0.3	23	22	0.7
1	Jun-01	LYC RUB	3	0.1	0.1	0.1	29	27	0.2
1	Oct-01	LYC RUB	10	0.4	0.1	0.0	22	30	0.5
1	Oct-97	MIK SCA	10	0.4	0.5	0.3	22	19	0.7
1	Oct-99	MIK SCA	22	0.9	0.8	0.5	19	19	1.3
1	May-00	MIK SCA	28	0.8	1.1	0.5	20	20	1.3
1	Jun-01	MIK SCA	3	0.1	0.1	0.1	29	27	0.2
1	Oct-01	MIK SCA	3	0.1	0.1	0.1	28	27	0.2
1	Oct-97	MUR KEI	57	2.2	1.9	1.1	9	8	3.3
1	Oct-99	MUR KEI	43	1.7	1.2	0.7	14	16	2.4
1	May-00	MUR KEI	87	2.6	3.8	1.8	13	11	4.4
1	Jun-01	MUR KEI	23	0.9	0.5	0.3	15	13	1.1
1	Oct-01	MUR KEI	9	0.4	0.2	0.1	23	21	0.5
1	May-00	NYS BIF	2	0.1	0.1	0.0	33	32	0.1
1	Oct-00	NYS BIF	1	0.0	0.0	0.0	28	26	0.1
1	Jun-01	NYS BIF	2	0.1	0.0	0.0	32	34	0.1
1	Oct-97	PLU ODO	6	0.2	0.2	0.1	26	26	0.3
1	Oct-99	PLU ODO	11	0.4	0.5	0.3	23	22	0.7
1	May-00	PLU ODO	7	0.2	0.4	0.2	28	24	0.4
1	Oct-00	PLU ODO	8	0.4	0.3	0.2	16	11	0.5
1	Jun-01	PLU ODO	11	0.4	0.3	0.2	20	20	0.6
1	Oct-01	PLU ODO	23	1.0	0.6	0.4	12	10	1.4
1	Oct-97	POL ARI	8	0.3	0.4	0.2	24	22	0.5
1	Oct-99	POL ARI	8	0.3	0.3	0.2	27	24	0.5
1	May-00	POL ARI	11	0.3	0.4	0.2	24	24	0.5

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
1	Oct-00	POL ARI	17	0.8	0.3	0.2	11	11	0.9
1	Jun-01	POL ARI	3	0.1	0.1	0.1	29	27	0.2
1	Oct-01	POL ARI	11	0.5	0.3	0.2	20	19	0.7
1	Oct-97	POL PUN	213	8.3	11.3	6.3	6	5	14.6
1	Oct-99	POL PUN	154	6.0	7.2	4.1	6	5	10.1
1	May-00	POL PUN	154	4.6	6.2	2.9	8	7	7.5
1	Oct-00	POL PUN	107	4.9	3.1	1.7	6	6	6.5
1	Jun-01	POL PUN	90	3.3	4.0	2.4	10	7	5.7
1	Oct-01	POL PUN	88	3.9	3.7	2.8	7	7	6.6
1	Oct-97	POL SAG	22	0.9	0.5	0.3	17	21	1.1
1	Oct-99	POL SAG	15	0.6	0.3	0.2	22	24	0.8
1	Oct-97	PON COR	2	0.1	0.1	0.1	30	28	0.1
1	Oct-99	PON COR	2	0.1	0.1	0.1	31	30	0.1
1	May-00	PON COR	5	0.1	0.2	0.1	30	28	0.2
1	Jun-01	PTI CAP	1	0.0	0.0	0.0	34	34	0.0
1	Oct-97	RHY COR	11	0.4	0.4	0.2	21	22	0.7
1	Oct-97	SAG LAN	3	0.1	0.1	0.1	29	28	0.2
1	Oct-99	SAG LAN	18	0.7	0.6	0.3	20	20	1.0
1	May-00	SAG LAN	109	3.2	4.6	2.2	10	9	5.4
1	Jun-01	SAG LAN	103	3.8	2.7	1.6	8	9	5.4
1	Oct-01	SAG LAN	11	0.5	0.2	0.1	20	23	0.6
1	May-00	SCI ROB	2	0.1	0.1	0.0	33	32	0.1
1	Oct-97	SCI TAB	236	9.2	6.3	3.5	4	6	12.7
1	Oct-99	SCI TAB	177	6.9	3.0	1.7	5	7	8.6
1	May-00	SCI TAB	294	8.8	9.9	4.6	4	5	13.4
1	Oct-00	SCI TAB	212	9.6	5.0	2.7	5	5	12.3
1	Jun-01	SCI TAB	346	12.9	8.7	5.1	4	4	18.0
1	Oct-01	SCI TAB	314	13.8	4.9	3.6	4	6	17.4
1	Oct-99	SES PUN	5	0.2	0.2	0.1	28	27	0.3
1	May-00	SES PUN	2	0.1	0.1	0.0	33	32	0.1
1	Oct-00	SES PUN	5	0.2	0.1	0.1	19	20	0.3
1	Jun-01	SES PUN	2	0.1	0.1	0.1	32	27	0.1
1	Oct-97	TYP ANG	36	1.4	1.0	0.6	13	12	2.0
1	Oct-99	TYP ANG	59	2.3	1.8	1.0	11	12	3.3
1	May-00	TYP ANG	93	2.8	2.6	1.2	12	14	4.0
1	Oct-00	TYP ANG	50	2.3	1.3	0.7	7	8	3.0
1	Jun-01	TYP ANG	120	4.5	2.5	1.5	7	10	5.9
1	Oct-01	TYP ANG	112	4.9	2.0	1.5	6	8	6.4
1	May-00	TYP DOM	9	0.3	0.3	0.1	26	27	0.4
1	Oct-00	TYP DOM	8	0.4	0.2	0.1	16	16	0.5
1	Jun-01	TYP DOM	9	0.3	0.4	0.2	21	17	0.6
1	Oct-01	TYP DOM	15	0.7	0.3	0.2	17	18	0.9
1	Oct-97	XYR IRI	40	1.6	1.0	0.6	12	14	2.1
1	Oct-99	XYR IRI	17	0.7	0.6	0.3	21	20	1.0
1	May-00	XYR IRI	6	0.2	0.2	0.1	29	28	0.3
1	Oct-00	XYR IRI	2	0.1	0.0	0.0	24	26	0.1
1	Oct-01	XYR IRI	1	0.0	0.0	0.0	33	31	0.1

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
1	Oct-97	ZIZ AQU	8	0.3	0.2	0.1	24	26	0.4
1	Oct-99	ZIZ AQU	10	0.4	0.2	0.1	26	27	0.5
1	Oct-00	ZIZ AQU	21	1.0	0.7	0.4	9	10	1.3
1	Jun-01	ZIZ AQU	6	0.2	0.2	0.1	23	23	0.3
1	Oct-01	ZIZ AQU	19	0.8	0.3	0.2	15	16	1.1
1	Oct-97	ZIZ MIL	421	16.4	35.6	19.8	2	2	36.2
1	Oct-99	ZIZ MIL	412	16.0	29.9	17.0	2	2	33.0
1	May-00	ZIZ MIL	385	11.5	24.4	11.4	3	3	22.9
1	Oct-00	ZIZ MIL	459	20.9	47.6	25.8	2	2	46.7
1	Jun-01	ZIZ MIL	389	14.5	21.3	12.6	3	3	27.0
1	Oct-01	ZIZ MIL	404	17.7	29.3	21.8	2	2	39.5
2	Oct-97	AST TEN	169	10.8	4.1	3.9	5	6	14.8
2	Oct-99	AST TEN	139	9.3	5.2	5.3	5	6	14.5
2	May-00	AST TEN	62	3.6	2.3	1.4	6	6	4.9
2	Oct-00	AST TEN	124	7.3	4.5	3.3	5	6	10.7
2	Jun-01	AST TEN	82	4.8	1.3	0.9	6	6	5.7
2	Oct-01	AST TEN	122	7.2	1.8	1.8	5	6	9.0
2	May-00	LIL CHI	40	2.3	0.8	0.5	7	7	2.8
2	Oct-97	PLU ODO	3	0.2	0.1	0.1	7	7	0.3
2	Oct-97	SCI ROB	321	20.6	11.9	11.4	2	4	32.0
2	Oct-99	SCI ROB	241	16.1	11.3	11.4	4	4	27.5
2	May-00	SCI ROB	398	22.8	38.0	22.5	2	3	45.3
2	Oct-00	SCI ROB	378	22.4	32.7	24.2	2	2	46.6
2	Jun-01	SCI ROB	393	23.0	43.3	29.3	2	1	52.3
2	Oct-01	SCI ROB	362	21.3	25.8	25.1	3	2	46.4
2	Oct-97	SCI TAB	292	18.7	16.9	16.2	3	2	35.0
2	Oct-99	SCI TAB	312	20.8	15.1	15.2	2	3	36.0
2	May-00	SCI TAB	357	20.5	39.1	23.2	3	2	43.6
2	Oct-00	SCI TAB	340	20.1	18.8	13.9	4	4	34.0
2	Jun-01	SCI TAB	342	20.0	24.1	16.3	4	4	36.3
2	Oct-01	SCI TAB	378	22.3	20.1	19.6	2	4	41.8
2	Oct-97	SPA ALT	262	16.8	16.9	16.2	4	3	33.0
2	Oct-99	SPA ALT	285	19.0	18.7	18.8	3	2	37.8
2	May-00	SPA ALT	346	19.8	37.4	22.2	4	4	42.0
2	Oct-00	SPA ALT	359	21.2	29.5	21.9	3	3	43.1
2	Jun-01	SPA ALT	379	22.2	33.6	22.8	3	3	45.0
2	Oct-01	SPA ALT	346	20.4	21.5	20.9	4	3	41.3
2	Oct-97	SPA CYN	116	7.4	7.3	7.0	6	5	14.5
2	Oct-99	SPA CYN	117	7.8	6.6	6.7	6	5	14.5
2	May-00	SPA CYN	120	6.9	9.5	5.6	5	5	12.5
2	Oct-00	SPA CYN	107	6.3	7.9	5.9	6	5	12.2
2	Jun-01	SPA CYN	98	5.7	7.0	4.8	5	5	10.5
2	Oct-01	SPA CYN	81	4.8	5.2	5.1	6	5	9.8
2	Oct-97	TYP ANG	395	25.4	47.1	45.1	1	1	70.5
2	Oct-99	TYP ANG	404	27.0	42.4	42.7	1	1	69.7
2	May-00	TYP ANG	422	24.2	41.7	24.7	1	1	48.9
2	Oct-00	TYP ANG	383	22.6	41.6	30.8	1	1	53.5

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
2	Jun-01	TYP ANG	415	24.3	38.2	25.9	1	2	50.2
2	Oct-01	TYP ANG	409	24.1	28.3	27.6	1	1	51.6
3	Oct-99	ALT PHI	6	0.4	0.2	0.2	17	17	0.6
3	May-00	ALT PHI	30	1.6	3.0	2.1	11	7	3.7
3	Oct-00	ALT PHI	6	0.4	0.2	0.1	15	15	0.5
3	Jun-01	ALT PHI	27	1.5	2.3	2.1	11	6	3.6
3	Oct-01	ALT PHI	21	1.4	0.3	0.4	12	13	1.8
3	Oct-97	AMA CAN	11	0.8	0.3	0.3	13	14	1.0
3	Oct-99	AMA CAN	3	0.2	0.1	0.1	19	19	0.3
3	May-00	AMA CAN	6	0.3	0.2	0.1	20	20	0.4
3	Oct-00	AMA CAN	7	0.4	0.3	0.2	14	14	0.7
3	Jun-01	AMA CAN	2	0.1	0.0	0.0	20	20	0.1
3	Oct-01	AMA CAN	27	1.8	0.8	0.9	11	11	2.7
3	Oct-97	API AME	2	0.1	0.1	0.1	18	16	0.2
3	Oct-99	AST ELL	6	0.4	0.3	0.3	17	13	0.7
3	May-00	AST ELL	18	1.0	1.0	0.7	12	13	1.7
3	Oct-00	AST ELL	42	2.7	2.5	2.1	9	7	4.8
3	Jun-01	AST ELL	6	0.3	0.3	0.3	17	15	0.6
3	Oct-01	AST ELL	5	0.3	0.3	0.4	16	13	0.7
3	Oct-99	AST TEN	29	1.8	1.1	1.1	10	10	3.0
3	Oct-00	AST TEN	77	4.9	3.4	2.9	7	5	7.8
3	Jun-01	AST TEN	58	3.2	1.6	1.4	9	10	4.6
3	Oct-01	AST TEN	112	7.3	3.4	4.0	5	4	11.3
3	Oct-97	BID LAE	66	4.6	5.9	6.0	8	4	10.6
3	Oct-99	BID LAE	80	5.1	2.8	2.9	7	5	8.0
3	May-00	BID LAE	66	3.6	3.5	2.5	8	6	6.0
3	Oct-00	BID LAE	17	1.1	0.3	0.3	12	13	1.4
3	Jun-01	BID LAE	21	1.2	0.8	0.7	13	12	1.9
3	Oct-01	BID LAE	36	2.3	0.9	1.1	9	9	3.5
3	Oct-97	BOL AST	5	0.3	0.1	0.1	16	16	0.4
3	Oct-99	BOL AST	8	0.5	0.3	0.3	16	14	0.8
3	May-00	BOL AST	9	0.5	0.2	0.1	18	20	0.6
3	Oct-00	BOL AST	6	0.4	0.2	0.1	15	15	0.5
3	Jun-01	BOL AST	11	0.6	0.3	0.2	15	16	0.8
3	Oct-99	CIC MAC	2	0.1	0.1	0.1	21	19	0.2
3	May-00	CIC MAC	8	0.4	0.2	0.1	19	20	0.6
3	Oct-97	CYP HAS	1	0.1	0.1	0.1	22	16	0.2
3	Oct-97	ELE CEL	102	7.0	4.8	4.8	5	6	11.9
3	Oct-99	ELE CEL	40	2.5	0.8	0.9	8	11	3.4
3	Oct-97	ELE FAL	26	1.8	1.8	1.9	10	9	3.7
3	Oct-99	ELE FAL	26	1.7	0.5	0.5	12	12	2.2
3	May-00	ELE FAL	15	0.8	1.1	0.8	13	12	1.6
3	Jun-01	ELE FAL	11	0.6	0.2	0.1	15	17	0.8
3	Oct-01	ELE FAL	7	0.5	0.1	0.1	14	16	0.6
3	May-00	JUN ELL	11	0.6	0.3	0.2	15	16	0.8
3	Jun-01	JUN ELL	3	0.2	0.0	0.0	19	21	0.2
3	Oct-97	LEE SP.	5	0.3	0.1	0.1	16	16	0.4

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
3	Oct-97	LIL CHI	10	0.7	0.2	0.2	14	15	0.9
3	Oct-99	LIL CHI	14	0.9	0.2	0.2	13	17	1.1
3	May-00	LIL CHI	88	4.8	1.4	1.0	7	10	5.8
3	Oct-00	LIL CHI	33	2.1	0.8	0.7	10	10	2.8
3	Jun-01	LIL CHI	89	4.9	1.7	1.5	7	9	6.4
3	Oct-01	LIL CHI	21	1.4	0.6	0.7	12	12	2.1
3	May-00	LUD PAL	10	0.5	0.3	0.2	17	19	0.7
3	Oct-97	OXY FIL	2	0.1	0.1	0.1	18	16	0.2
3	Oct-97	PEL VIR	2	0.1	0.1	0.1	18	16	0.2
3	May-00	PEL VIR	14	0.8	0.8	0.6	14	14	1.3
3	Jun-01	PEL VIR	12	0.7	0.4	0.4	14	14	1.0
3	Oct-01	PEL VIR	6	0.4	0.2	0.2	15	15	0.6
3	Oct-97	PLU ODO	16	1.1	0.7	0.7	11	11	1.8
3	Oct-99	PLU ODO	37	2.4	1.3	1.4	9	8	3.7
3	May-00	PLU ODO	42	2.3	1.4	1.0	10	11	3.2
3	Oct-00	PLU ODO	88	5.6	1.9	1.6	6	8	7.2
3	Jun-01	PLU ODO	74	4.1	1.9	1.6	8	7	5.8
3	Oct-01	PLU ODO	55	3.6	1.6	1.9	7	7	5.5
3	Oct-97	PLU ROS	10	0.7	0.3	0.3	14	12	1.0
3	Oct-97	POL PUN	90	6.2	7.3	7.4	6	3	13.6
3	Oct-99	POL PUN	124	7.9	6.6	6.7	3	4	14.6
3	May-00	POL PUN	126	6.8	10.2	7.2	4	5	14.0
3	Oct-00	POL PUN	124	7.9	4.4	3.6	3	4	11.5
3	Jun-01	POL PUN	90	5.0	2.5	2.2	6	5	7.2
3	Oct-01	POL PUN	74	4.8	2.6	3.1	6	6	7.9
3	Oct-97	PON COR	2	0.1	0.1	0.1	18	16	0.2
3	Oct-99	PON COR	3	0.2	0.1	0.1	19	19	0.3
3	May-00	PON COR	5	0.3	0.3	0.2	21	16	0.5
3	Jun-01	PON COR	5	0.3	0.1	0.1	18	18	0.4
3	Oct-97	SAG LAN	107	7.4	2.5	2.5	4	8	9.9
3	Oct-99	SAG LAN	97	6.2	2.1	2.1	6	6	8.3
3	May-00	SAG LAN	273	14.8	11.0	7.8	2	4	22.6
3	Oct-00	SAG LAN	24	1.5	0.6	0.5	11	11	2.0
3	Jun-01	SAG LAN	277	15.4	5.5	4.9	2	4	20.3
3	Oct-01	SAG LAN	31	2.0	0.8	0.9	10	10	3.0
3	Oct-97	SCI PUN	76	5.2	3.1	3.1	7	7	8.4
3	Oct-99	SCI PUN	105	6.7	7.8	8.0	5	3	14.7
3	May-00	SCI PUN	122	6.6	15.3	10.8	5	2	17.4
3	Oct-00	SCI PUN	121	7.7	13.4	11.2	4	3	18.9
3	Jun-01	SCI PUN	164	9.1	16.8	14.8	4	2	24.0
3	Oct-01	SCI PUN	174	11.3	14.3	17.0	3	2	28.3
3	Oct-99	SCI ROB	14	0.9	0.3	0.3	13	14	1.1
3	May-00	SCI ROB	58	3.1	2.4	1.7	9	8	4.9
3	Oct-00	SCI ROB	14	0.9	0.5	0.4	13	12	1.3
3	Jun-01	SCI ROB	55	3.1	1.8	1.6	10	8	4.7
3	Oct-97	SCI TAB	564	38.9	50.8	51.6	1	1	90.5
3	Oct-99	SCI TAB	581	37.0	57.2	58.3	1	1	95.3

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
3	May-00	SCI TAB	599	32.5	73.6	51.9	1	1	84.4
3	Oct-00	SCI TAB	581	37.1	64.2	53.3	1	1	90.3
3	Jun-01	SCI TAB	577	32.1	68.5	60.6	1	1	92.7
3	Oct-01	SCI TAB	574	37.3	42.8	50.8	1	1	88.1
3	May-00	SIU SUA	2	0.1	0.1	0.1	23	23	0.2
3	Jun-01	SIU SUA	2	0.1	0.1	0.1	20	18	0.2
3	Oct-97	SPA ALT	118	8.1	4.8	4.9	3	5	13.0
3	Oct-99	SPA ALT	120	7.6	1.4	1.5	4	7	9.1
3	May-00	SPA ALT	106	5.7	2.3	1.6	6	9	7.3
3	Oct-00	SPA ALT	109	7.0	1.3	1.1	5	9	8.1
3	Jun-01	SPA ALT	95	5.3	1.5	1.3	5	11	6.6
3	Oct-01	SPA ALT	121	7.9	1.5	1.8	4	8	9.6
3	Oct-97	SPA CYN	29	2.0	1.4	1.4	9	10	3.4
3	Oct-99	SPA CYN	29	1.8	1.3	1.3	10	9	3.1
3	May-00	SPA CYN	11	0.6	0.7	0.5	15	15	1.1
3	Oct-00	SPA CYN	45	2.9	3.2	2.6	8	6	5.5
3	Jun-01	SPA CYN	23	1.3	0.8	0.7	12	13	1.9
3	Oct-01	SPA CYN	44	2.9	2.9	3.5	8	5	6.3
3	Oct-97	TYP ANG	12	0.8	0.3	0.3	12	12	1.1
3	May-00	TYP ANG	1	0.1	0.0	0.0	24	24	0.1
3	Oct-99	ZIZ AQU	11	0.7	0.3	0.3	15	14	1.0
3	May-00	ZIZ AQU	5	0.3	0.3	0.2	21	16	0.5
3	Oct-00	ZIZ AQU	2	0.1	0.1	0.1	17	17	0.2
3	Oct-97	ZIZ MIL	193	13.3	14.0	14.2	2	2	27.5
3	Oct-99	ZIZ MIL	236	15.0	13.4	13.7	2	2	28.7
3	May-00	ZIZ MIL	219	11.9	12.3	8.7	3	3	20.5
3	Oct-00	ZIZ MIL	272	17.3	23.3	19.3	2	2	36.7
3	Jun-01	ZIZ MIL	196	10.9	6.0	5.3	3	3	16.2
3	Oct-01	ZIZ MIL	232	15.1	11.1	13.2	2	3	28.2
4	Jun-01	AGA PUR	4	0.2	0.2	0.1	23	19	0.3
4	May-00	ALT PHI	12	0.5	1.3	0.5	14	11	1.0
4	Jun-01	ALT PHI	16	0.7	0.9	0.6	13	10	1.3
4	Oct-01	ALT PHI	14	0.6	0.9	0.8	12	10	1.5
4	Oct-97	AMA CAN	3	0.2	0.1	0.1	12	11	0.3
4	Oct-99	AMA CAN	2	0.1	0.1	0.1	10	10	0.2
4	May-00	AMA CAN	10	0.4	0.2	0.1	15	15	0.5
4	Jun-01	AMA CAN	10	0.4	0.2	0.1	18	18	0.6
4	Oct-01	AMA CAN	15	0.7	0.4	0.4	11	12	1.0
4	Oct-97	AST ELL	187	10.3	13.3	12.0	4	3	22.3
4	Oct-99	AST ELL	281	15.8	26.0	23.7	3	3	39.5
4	May-00	AST ELL	289	11.2	38.6	16.0	5	3	27.1
4	Oct-00	AST ELL	372	19.6	38.5	25.0	3	2	44.7
4	Jun-01	AST ELL	297	12.6	33.0	23.2	4	1	35.8
4	Oct-01	AST ELL	290	13.2	19.9	18.1	4	2	31.3
4	May-00	AST NOV	2	0.1	0.1	0.0	20	17	0.1
4	Oct-97	AST TEN	3	0.2	0.1	0.1	12	12	0.3
4	Jun-01	AST TEN	2	0.1	0.1	0.1	25	24	0.2

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
4	Oct-01	AST TEN	5	0.2	0.1	0.1	14	14	0.3
4	Oct-97	BID LAE	156	8.6	6.7	6.0	6	5	14.6
4	Oct-99	BID LAE	176	9.9	6.8	6.2	5	4	16.1
4	May-00	BID LAE	301	11.7	24.6	10.2	4	6	21.8
4	Oct-00	BID LAE	55	2.9	1.2	0.8	6	7	3.7
4	Jun-01	BID LAE	92	3.9	1.8	1.3	6	8	5.2
4	Oct-01	BID LAE	131	6.0	4.3	3.9	6	7	9.9
4	Jun-01	BID MIT	2	0.1	0.1	0.1	25	24	0.2
4	Oct-99	BOL AST	2	0.1	0.1	0.1	10	10	0.2
4	Jun-01	BOL AST	4	0.2	0.1	0.1	23	23	0.2
4	Oct-97	CIC MAC	2	0.1	0.1	0.1	16	12	0.2
4	May-00	CIC MAC	2	0.1	0.1	0.0	20	17	0.1
4	Jun-01	CIC MAC	10	0.4	0.2	0.1	18	19	0.6
4	Oct-97	CYP HAS	2	0.1	0.0	0.0	16	17	0.1
4	Oct-99	CYP HAS	1	0.1	0.1	0.1	13	10	0.1
4	Jun-01	CYP HAS	2	0.1	0.1	0.1	25	24	0.2
4	Oct-01	CYP HAS	3	0.1	0.0	0.0	16	18	0.2
4	Oct-97	CYP STE	4	0.2	0.1	0.1	11	12	0.3
4	Oct-01	CYP STE	3	0.1	0.1	0.1	16	14	0.2
4	Oct-97	ELE CEL	34	1.9	0.2	0.2	8	10	2.1
4	Oct-97	ELE FAL	167	9.2	4.2	3.8	5	7	13.0
4	Oct-99	ELE FAL	61	3.4	0.7	0.6	6	7	4.0
4	May-00	ELE FAL	284	11.0	26.8	11.1	6	5	22.1
4	Oct-00	ELE FAL	150	7.9	8.8	5.7	5	5	13.6
4	Jun-01	ELE FAL	256	10.9	14.8	10.4	5	5	21.2
4	Oct-01	ELE FAL	265	12.1	11.2	10.2	5	4	22.3
4	Oct-97	ELE QUA	26	1.4	0.5	0.4	9	8	1.9
4	Jun-01	ELE QUA	30	1.3	0.6	0.4	11	13	1.7
4	May-00	ELE VIV	2	0.1	0.1	0.0	20	17	0.1
4	Jun-01	ERE HIE	1	0.0	0.1	0.1	28	24	0.1
4	Jun-01	ERY AQU	5	0.2	0.2	0.1	21	19	0.4
4	May-00	GAL OBT	4	0.2	0.1	0.0	18	17	0.2
4	May-00	IRI VIR	3	0.1	0.1	0.0	19	17	0.2
4	Jun-01	IRI VIR	14	0.6	0.3	0.2	14	17	0.8
4	May-00	JUN ELL	56	2.2	1.2	0.5	9	13	2.7
4	Jun-01	JUN ELL	27	1.1	0.6	0.4	12	12	1.6
4	May-00	JUN POL	2	0.1	0.1	0.0	20	17	0.1
4	May-00	LIL CHI	5	0.2	0.1	0.0	16	17	0.2
4	Jun-01	LIL CHI	39	1.7	0.8	0.6	10	11	2.2
4	Oct-01	LIL CHI	52	2.4	0.8	0.7	8	11	3.1
4	May-00	LUD PAL	65	2.5	4.2	1.7	8	8	4.3
4	Jun-01	LUD PAL	13	0.6	0.4	0.3	15	16	0.8
4	Oct-97	PAN HEM	54	3.0	4.8	4.3	7	6	7.3
4	Oct-99	PAN HEM	53	3.0	2.7	2.5	7	6	5.4
4	May-00	PAN HEM	75	2.9	6.5	2.7	7	7	5.6
4	Oct-00	PAN HEM	27	1.4	1.2	0.8	8	8	2.2
4	Jun-01	PAN HEM	90	3.8	6.2	4.3	7	6	8.2

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
4	Oct-01	PAN HEM	80	3.6	6.6	6.0	7	6	9.6
4	Jun-01	PEL VIR	1	0.0	0.1	0.1	28	24	0.1
4	Oct-97	PLU ODO	12	0.7	0.3	0.3	10	9	0.9
4	Jun-01	PLU ODO	13	0.6	0.4	0.3	15	15	0.8
4	Oct-01	PLU ODO	32	1.5	1.1	1.0	9	8	2.5
4	Oct-97	POL PUN	361	19.9	23.5	21.1	2	2	41.0
4	Oct-99	POL PUN	464	26.2	28.4	25.9	1	2	52.1
4	May-00	POL PUN	455	17.6	49.7	20.5	2	2	38.2
4	Oct-00	POL PUN	370	19.5	21.0	13.7	4	4	33.2
4	Jun-01	POL PUN	405	17.2	29.9	21.0	3	2	38.2
4	Oct-01	POL PUN	397	18.1	16.2	14.7	2	3	32.8
4	Oct-97	PON COR	3	0.2	0.1	0.1	12	12	0.3
4	Oct-99	PON COR	2	0.1	0.1	0.1	10	10	0.2
4	May-00	PON COR	5	0.2	0.4	0.2	16	14	0.4
4	Jun-01	PON COR	13	0.6	0.5	0.4	15	14	0.9
4	May-00	PTI CAP	25	1.0	1.3	0.5	12	11	1.5
4	Jun-01	PTI CAP	1	0.0	0.0	0.0	28	30	0.0
4	Oct-01	RHY COR	2	0.1	0.1	0.1	18	14	0.2
4	May-00	RUM VER	15	0.6	0.2	0.1	13	15	0.7
4	Jun-01	RUM VER	5	0.2	0.1	0.1	21	24	0.3
4	Oct-01	RUM VER	5	0.2	0.1	0.1	14	14	0.3
4	Oct-97	SAG LAN	1	0.1	0.0	0.0	18	18	0.1
4	May-00	SAG LAN	33	1.3	2.0	0.8	11	9	2.1
4	Jun-01	SAG LAN	48	2.0	1.2	0.8	9	9	2.9
4	Oct-99	SCI ROB	9	0.5	0.3	0.3	9	9	0.8
4	May-00	SCI ROB	44	1.7	1.5	0.6	10	10	2.3
4	Oct-00	SCI ROB	20	1.1	0.4	0.3	9	10	1.3
4	Jun-01	SCI ROB	64	2.7	2.2	1.5	8	7	4.3
4	Oct-01	SCI ROB	12	0.5	0.3	0.3	13	13	0.8
4	Oct-97	SCI TAB	351	19.3	10.8	9.7	3	4	29.0
4	Oct-99	SCI TAB	250	14.1	3.9	3.6	4	5	17.6
4	May-00	SCI TAB	475	18.4	51.9	21.5	1	1	39.8
4	Oct-00	SCI TAB	390	20.6	25.7	16.7	2	3	37.3
4	Jun-01	SCI TAB	467	19.8	25.2	17.7	1	3	37.5
4	Oct-01	SCI TAB	390	17.8	9.7	8.8	3	5	26.6
4	May-00	SES PUN	1	0.0	0.0	0.0	24	24	0.0
4	Oct-00	SPA ALT	9	0.5	0.6	0.4	10	9	0.9
4	Oct-97	SPA CYN	3	0.2	0.1	0.1	12	12	0.3
4	Oct-99	SPA CYN	15	0.8	0.6	0.5	8	8	1.4
4	Oct-00	SPA CYN	38	2.0	3.0	2.0	7	6	4.0
4	Jun-01	SPA CYN	6	0.3	0.2	0.1	20	19	0.4
4	Oct-01	SPA CYN	29	1.3	0.9	0.8	10	9	2.1
4	Oct-97	ZIZ MIL	446	24.6	46.5	41.7	1	1	66.2
4	Oct-99	ZIZ MIL	458	25.8	39.9	36.4	2	1	62.2
4	May-00	ZIZ MIL	418	16.2	30.8	12.7	3	4	28.9
4	Oct-00	ZIZ MIL	465	24.5	53.4	34.7	1	1	59.3
4	Jun-01	ZIZ MIL	422	17.9	21.9	15.4	2	4	33.3

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
4	Oct-01	ZIZ MIL	468	21.3	37.4	33.9	1	1	55.3
5	May-00	AGA PUR	3	0.2	0.1	0.1	23	24	0.2
5	Jun-01	AGA PUR	13	0.6	1.3	0.9	15	9	1.5
5	Oct-97	ALT PHI	22	1.6	0.6	0.6	11	11	2.2
5	Oct-99	ALT PHI	11	0.7	0.5	0.4	13	12	1.1
5	May-00	ALT PHI	33	1.8	4.1	2.8	13	8	4.6
5	Oct-00	ALT PHI	27	1.9	1.3	1.7	8	7	3.6
5	Jun-01	ALT PHI	30	1.4	4.0	2.7	10	7	4.1
5	Oct-01	ALT PHI	38	2.2	3.2	2.5	9	6	4.6
5	Oct-97	AMA CAN	2	0.1	0.1	0.1	17	16	0.2
5	Jun-01	AMA CAN	15	0.7	0.3	0.2	13	18	0.9
5	Oct-01	AMA CAN	11	0.6	0.2	0.2	13	13	0.8
5	Oct-99	AMP ARB	2	0.1	0.1	0.1	23	18	0.2
5	May-00	AMP ARB	2	0.1	0.0	0.0	26	27	0.1
5	Jun-01	AMP ARB	4	0.2	0.2	0.1	23	20	0.3
5	Oct-97	AST ELL	1	0.1	0.1	0.1	22	16	0.2
5	Oct-99	AST ELL	12	0.8	0.3	0.3	12	14	1.0
5	May-00	AST ELL	8	0.4	0.3	0.2	19	17	0.6
5	Oct-00	AST ELL	2	0.1	0.1	0.1	16	16	0.3
5	Jun-01	AST ELL	13	0.6	0.5	0.3	15	16	1.0
5	Oct-01	AST ELL	8	0.5	0.2	0.2	14	13	0.6
5	Oct-99	AST NOV	3	0.2	0.1	0.1	21	18	0.3
5	Oct-97	AST TEN	44	3.2	1.1	1.1	7	8	4.3
5	Oct-99	AST TEN	176	11.1	5.5	5.0	4	4	16.1
5	May-00	AST TEN	56	3.0	2.1	1.5	10	10	4.5
5	Oct-00	AST TEN	245	17.3	9.8	12.6	3	4	29.9
5	Jun-01	AST TEN	290	13.8	22.9	15.2	3	3	29.1
5	Oct-01	AST TEN	331	18.8	15.4	12.0	2	3	30.7
5	Oct-97	BAC HAL	15	1.1	1.7	1.7	13	7	2.8
5	Oct-99	BAC HAL	3	0.2	0.1	0.1	21	18	0.3
5	May-00	BAC HAL	5	0.3	0.2	0.1	21	19	0.4
5	Oct-00	BAC HAL	10	0.7	0.8	1.0	9	8	1.7
5	Jun-01	BAC HAL	9	0.4	1.3	0.9	19	9	1.3
5	Oct-01	BAC HAL	12	0.7	0.9	0.7	12	11	1.4
5	Oct-97	BID LAE	45	3.3	4.0	3.9	6	4	7.2
5	Oct-99	BID LAE	93	5.9	2.4	2.2	5	6	8.0
5	May-00	BID LAE	111	5.9	5.1	3.5	5	5	9.5
5	Oct-00	BID LAE	1	0.1	0.0	0.0	18	18	0.1
5	Jun-01	BID LAE	30	1.4	0.8	0.5	10	13	2.0
5	Oct-01	BID LAE	50	2.8	1.8	1.4	8	7	4.2
5	Jun-01	BID MIT	1	0.0	0.1	0.1	29	23	0.1
5	Oct-00	BOL AST	6	0.4	0.3	0.4	12	14	0.8
5	Jun-01	CAL SEP	5	0.2	0.1	0.1	22	23	0.3
5	Oct-97	CIC MAC	2	0.1	0.1	0.1	17	16	0.2
5	May-00	CIC MAC	4	0.2	0.2	0.1	22	19	0.4
5	Jun-01	CIC MAC	10	0.5	0.3	0.2	18	18	0.7
5	Oct-97	CYP HAS	1	0.1	0.0	0.0	22	23	0.1

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
5	Oct-99	CYP HAS	5	0.3	0.0	0.0	18	23	0.3
5	Jun-01	CYP HAS	1	0.0	0.0	0.0	29	30	0.1
5	May-00	CYP VIR	3	0.2	0.2	0.1	23	19	0.3
5	Oct-97	ELE FAL	300	21.9	45.7	44.7	2	1	66.5
5	Oct-99	ELE FAL	317	20.1	50.7	45.6	2	1	65.6
5	May-00	ELE FAL	339	18.2	46.0	31.7	2	1	49.9
5	Oct-00	ELE FAL	302	21.3	11.9	15.3	2	3	36.6
5	Jun-01	ELE FAL	317	15.1	40.9	27.2	2	2	42.3
5	Oct-01	ELE FAL	307	17.4	44.3	34.3	3	1	51.7
5	Jun-01	ERY AQU	2	0.1	0.1	0.1	27	23	0.2
5	Oct-97	EUT CAR	2	0.1	0.1	0.1	17	16	0.2
5	Oct-99	EUT CAR	11	0.7	0.2	0.2	13	16	0.9
5	May-00	EUT CAR	7	0.4	0.2	0.1	20	19	0.5
5	Oct-00	EUT CAR	5	0.4	0.4	0.5	15	11	0.9
5	Oct-01	EUT CAR	8	0.5	0.2	0.2	14	13	0.6
5	Oct-97	HYD UMB	41	3.0	0.1	0.1	9	22	3.1
5	Oct-99	HYD UMB	2	0.1	0.0	0.0	23	23	0.1
5	May-00	HYD UMB	103	5.5	3.3	2.3	7	9	7.8
5	Jun-01	HYD UMB	33	1.6	0.8	0.5	9	13	2.1
5	Oct-97	JUN EFF	4	0.3	0.1	0.1	16	15	0.4
5	Oct-99	JUN EFF	5	0.3	0.1	0.1	18	18	0.4
5	May-00	JUN EFF	9	0.5	0.3	0.2	17	17	0.7
5	Jun-01	JUN EFF	2	0.1	0.1	0.1	27	23	0.2
5	May-00	JUN ELL	51	2.7	1.0	0.7	11	13	3.4
5	Jun-01	JUN ELL	6	0.3	0.2	0.1	21	20	0.4
5	May-00	JUN MAR	18	1.0	0.6	0.4	14	16	1.4
5	Oct-97	LIL CHI	18	1.3	0.6	0.6	12	11	1.9
5	Oct-99	LIL CHI	64	4.1	1.5	1.3	8	9	5.4
5	May-00	LIL CHI	106	5.7	7.9	5.5	6	4	11.1
5	Jun-01	LIL CHI	240	11.5	9.9	6.6	4	4	18.0
5	Oct-01	LIL CHI	238	13.5	11.8	9.1	4	4	22.6
5	Oct-99	LUD PIL	7	0.4	0.2	0.2	17	16	0.6
5	Oct-00	PAN DIC	7	0.5	0.4	0.5	11	11	1.0
5	May-00	PHY AME	1	0.1	0.1	0.1	27	24	0.1
5	Oct-97	PLU ODO	74	5.4	1.9	1.9	4	6	7.3
5	Oct-99	PLU ODO	69	4.4	2.2	1.9	7	7	6.3
5	May-00	PLU ODO	73	3.9	1.8	1.2	9	11	5.2
5	Oct-00	PLU ODO	109	7.7	2.7	3.5	5	5	11.2
5	Jun-01	PLU ODO	147	7.0	3.8	2.5	7	8	9.6
5	Oct-01	PLU ODO	62	3.5	1.6	1.3	6	8	4.8
5	Oct-97	PLU ROS	2	0.1	0.1	0.1	17	16	0.2
5	Oct-97	POL ARI	2	0.1	0.1	0.1	17	16	0.2
5	Oct-99	POL ARI	5	0.3	0.1	0.1	18	18	0.4
5	Oct-00	POL ARI	6	0.4	0.4	0.5	12	11	0.9
5	Oct-97	POL PUN	67	4.9	3.0	2.9	5	5	7.8
5	Oct-99	POL PUN	47	3.0	2.8	2.5	9	5	5.5
5	May-00	POL PUN	75	4.0	5.1	3.5	8	5	7.5

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
5	Jun-01	POL PUN	3	0.1	0.1	0.1	24	23	0.2
5	Oct-99	RUM VER	9	0.6	0.3	0.3	15	14	0.8
5	May-00	RUM VER	14	0.7	0.8	0.6	15	15	1.3
5	Jun-01	RUM VER	15	0.7	1.3	0.9	13	9	1.6
5	Oct-97	SAG LAN	42	3.1	0.8	0.8	8	9	3.9
5	Oct-99	SAG LAN	23	1.5	0.5	0.5	10	11	1.9
5	May-00	SAG LAN	174	9.3	4.5	3.1	3	7	12.4
5	Oct-00	SAG LAN	2	0.1	0.0	0.0	16	17	0.2
5	Jun-01	SAG LAN	175	8.4	5.1	3.4	5	6	11.8
5	Oct-01	SAG LAN	6	0.3	0.1	0.0	16	18	0.4
5	May-00	SAU CER	13	0.7	1.0	0.7	16	14	1.4
5	Jun-01	SAU CER	7	0.3	0.2	0.1	20	20	0.5
5	May-00	SCI ROB	3	0.2	0.1	0.1	23	24	0.2
5	Jun-01	SCI ROB	17	0.8	0.7	0.5	12	15	1.3
5	Oct-01	SCI ROB	5	0.3	0.1	0.1	18	17	0.4
5	Oct-97	SCI TAB	465	33.9	18.8	18.3	1	3	52.2
5	Oct-99	SCI TAB	420	26.6	18.7	16.8	1	3	43.4
5	May-00	SCI TAB	453	24.3	45.2	31.2	1	2	55.5
5	Oct-00	SCI TAB	429	30.2	32.9	42.3	1	1	72.5
5	Jun-01	SCI TAB	469	22.4	47.3	31.4	1	1	53.8
5	Oct-01	SCI TAB	443	25.1	39.4	30.6	1	2	55.7
5	Oct-00	SOL SEM	6	0.4	0.2	0.3	12	15	0.7
5	Jun-01	SOL SEM	3	0.1	0.1	0.1	24	23	0.2
5	Oct-01	SOL SEM	6	0.3	0.2	0.2	16	13	0.5
5	Oct-97	SPA ALT	7	0.5	0.2	0.2	14	13	0.7
5	Oct-99	SPA ALT	9	0.6	0.5	0.4	15	12	1.0
5	May-00	SPA ALT	9	0.5	0.2	0.1	17	19	0.6
5	Oct-00	SPA ALT	9	0.6	0.5	0.6	10	10	1.3
5	Jun-01	SPA ALT	11	0.5	0.5	0.3	17	16	0.9
5	Oct-01	SPA ALT	22	1.2	1.3	1.0	10	9	2.3
5	Oct-97	TYP ANG	37	2.7	0.7	0.6	10	10	3.3
5	Oct-99	TYP ANG	90	5.7	1.6	1.4	6	8	7.1
5	May-00	TYP ANG	41	2.2	1.1	0.8	12	12	3.0
5	Oct-00	TYP ANG	58	4.1	1.3	1.7	6	6	5.8
5	Jun-01	TYP ANG	60	2.9	1.1	0.7	8	12	3.6
5	Oct-01	TYP ANG	56	3.2	1.1	0.9	7	10	4.1
5	Oct-97	ZIZ AQU	5	0.4	0.2	0.2	15	13	0.6
5	Oct-99	ZIZ AQU	18	1.1	0.6	0.5	11	10	1.7
5	Oct-00	ZIZ AQU	35	2.5	0.6	0.8	7	9	3.3
5	Jun-01	ZIZ AQU	3	0.1	0.1	0.1	24	23	0.2
5	Oct-01	ZIZ AQU	17	1.0	0.4	0.3	11	12	1.3
5	Oct-97	ZIZ MIL	174	12.7	22.2	21.7	3	2	34.4
5	Oct-99	ZIZ MIL	178	11.3	22.3	20.0	3	2	31.3
5	May-00	ZIZ MIL	153	8.2	13.4	9.2	4	3	17.4
5	Oct-00	ZIZ MIL	160	11.3	14.1	18.1	4	2	29.4
5	Jun-01	ZIZ MIL	163	7.8	6.3	4.2	6	5	12.0
5	Oct-01	ZIZ MIL	144	8.2	6.7	5.2	5	5	13.4

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
6	Oct-97	ACE RUB	9	0.5	0.9	0.7	20	10	1.2
6	Oct-99	ACE RUB	11	0.6	0.6	0.5	18	15	1.1
6	May-00	ACE RUB	9	0.4	0.6	0.4	23	17	0.8
6	Oct-00	ACE RUB	10	0.6	0.3	0.3	17	18	0.9
6	Jun-01	ACE RUB	7	0.3	0.2	0.1	25	23	0.5
6	Oct-01	ACE RUB	6	0.4	0.2	0.2	22	20	0.5
6	Oct-97	AND GLO	7	0.4	0.3	0.2	21	22	0.6
6	Oct-99	AND GLO	10	0.6	0.3	0.2	19	18	0.8
6	Oct-00	AND GLO	3	0.2	0.2	0.2	28	25	0.4
6	Oct-01	AND GLO	3	0.2	0.1	0.1	27	26	0.3
6	Oct-97	AST ELL	175	9.6	8.5	6.5	4	3	16.1
6	Oct-99	AST ELL	220	13.0	14.0	10.9	3	3	23.8
6	May-00	AST ELL	237	10.4	17.1	11.9	4	3	22.3
6	Oct-00	AST ELL	178	11.1	8.2	7.0	4	4	18.0
6	Jun-01	AST ELL	194	8.9	9.7	6.9	5	4	15.8
6	Oct-01	AST ELL	161	9.5	4.5	4.2	4	4	13.7
6	Oct-97	BAC HAL	11	0.6	0.4	0.3	18	17	0.9
6	Oct-99	BAC HAL	12	0.7	1.0	0.8	15	11	1.5
6	May-00	BAC HAL	16	0.7	0.6	0.4	17	17	1.1
6	Oct-00	BAC HAL	18	1.1	1.1	0.9	13	10	2.1
6	Jun-01	BAC HAL	11	0.5	1.3	0.9	18	11	1.4
6	Oct-01	BAC HAL	18	1.1	0.7	0.7	12	11	1.7
6	Oct-97	BID LAE	2	0.1	0.0	0.0	33	40	0.1
6	May-00	BID LAE	1	0.0	0.0	0.0	41	43	0.1
6	Oct-01	BID LAE	3	0.2	0.1	0.1	27	26	0.3
6	Jun-01	BOL AST	3	0.1	0.1	0.1	30	29	0.2
6	Oct-97	CAL SEP	2	0.1	0.1	0.1	33	31	0.2
6	Jun-01	CAL SEP	5	0.2	0.1	0.1	27	29	0.3
6	Oct-00	CAR ALA	1	0.1	0.0	0.0	34	32	0.1
6	Jun-01	CAR COM	2	0.1	0.1	0.1	34	29	0.2
6	Oct-97	CAR LON	7	0.4	0.3	0.2	21	22	0.6
6	May-00	CAR LON	8	0.4	0.3	0.2	25	22	0.6
6	May-00	CAR SP1	3	0.1	0.2	0.1	35	26	0.3
6	Jun-01	CAR SP1	3	0.1	0.1	0.1	30	29	0.2
6	May-00	CAR SP2	1	0.0	0.1	0.1	41	34	0.1
6	Oct-97	CIC MAC	1	0.1	0.0	0.0	41	41	0.1
6	May-00	CIC MAC	5	0.2	0.1	0.1	30	34	0.3
6	Jun-01	CIC MAC	8	0.4	0.5	0.4	22	18	0.7
6	Oct-01	CIC MAC	3	0.2	0.1	0.1	27	26	0.3
6	Oct-97	CIN ARU	2	0.1	0.1	0.1	33	31	0.2
6	Oct-97	CYP HAS	18	1.0	0.4	0.3	13	16	1.3
6	Oct-99	CYP HAS	3	0.2	0.0	0.0	26	28	0.2
6	May-00	CYP HAS	1	0.0	0.1	0.1	41	34	0.1
6	Oct-00	CYP HAS	22	1.4	0.4	0.3	12	15	1.7
6	Jun-01	CYP HAS	4	0.2	0.1	0.1	29	28	0.3
6	Oct-01	CYP HAS	6	0.4	0.2	0.2	22	20	0.5
6	Oct-97	CYP STE	2	0.1	0.1	0.1	33	31	0.2

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
6	Oct-01	CYP STE	2	0.1	0.1	0.1	30	26	0.2
6	Oct-00	ECH CRU	2	0.1	0.1	0.1	32	29	0.2
6	Oct-97	ELE CEL	26	1.4	0.7	0.5	10	12	2.0
6	Oct-99	ELE CEL	29	1.7	0.9	0.7	11	14	2.4
6	Oct-97	ELE FAL	408	22.3	42.9	32.8	1	1	55.1
6	Oct-99	ELE FAL	408	24.0	41.6	32.3	1	2	56.3
6	May-00	ELE FAL	389	17.1	42.7	29.6	1	1	46.7
6	Oct-00	ELE FAL	389	24.2	40.5	34.5	1	2	58.6
6	Jun-01	ELE FAL	408	18.8	52.0	36.7	2	1	55.5
6	Oct-01	ELE FAL	400	23.7	43.1	40.3	1	1	64.0
6	Oct-97	ELE QUA	7	0.4	0.4	0.3	21	17	0.7
6	May-00	ELE QUA	11	0.5	0.2	0.1	20	26	0.6
6	Oct-00	ELE QUA	12	0.7	0.2	0.2	14	20	0.9
6	May-00	ELE VIV	6	0.3	0.1	0.1	29	34	0.3
6	Oct-00	ELE VIV	5	0.3	0.2	0.2	24	20	0.5
6	Oct-01	ELE VIV	2	0.1	0.1	0.1	30	26	0.2
6	Oct-97	EUP LEP	2	0.1	0.1	0.1	33	31	0.2
6	Oct-01	FUI BRE	1	0.1	0.0	0.0	34	33	0.1
6	May-00	GAL OBT	8	0.4	0.2	0.1	25	26	0.5
6	Oct-97	HYD UMB	12	0.7	0.2	0.1	17	30	0.8
6	Oct-99	HYD UMB	68	4.0	1.0	0.7	6	13	4.8
6	May-00	HYD UMB	223	9.8	3.6	2.5	5	9	12.3
6	Oct-00	HYD UMB	39	2.4	0.4	0.3	6	14	2.8
6	Jun-01	HYD UMB	236	10.9	4.0	2.8	4	6	13.7
6	Oct-01	HYD UMB	16	0.9	0.3	0.3	15	18	1.3
6	Oct-97	HYP HYP	2	0.1	0.1	0.1	33	31	0.2
6	Oct-97	HYP MUT	5	0.3	0.2	0.2	27	25	0.4
6	Oct-97	IRI VIR	11	0.6	0.3	0.2	18	21	0.8
6	Oct-99	IRI VIR	22	1.3	0.6	0.5	12	16	1.8
6	May-00	IRI VIR	73	3.2	2.7	1.9	7	10	5.1
6	Oct-00	IRI VIR	10	0.6	0.2	0.2	17	19	0.8
6	Jun-01	IRI VIR	60	2.8	2.3	1.6	7	10	4.4
6	Oct-01	IRI VIR	22	1.3	0.5	0.5	11	15	1.8
6	Oct-97	JUN EFF	17	0.9	0.5	0.4	16	15	1.3
6	Oct-99	JUN EFF	16	0.9	1.5	1.2	14	9	2.1
6	May-00	JUN EFF	10	0.4	0.4	0.3	21	20	0.7
6	Oct-00	JUN EFF	7	0.4	0.2	0.2	20	20	0.6
6	Jun-01	JUN EFF	9	0.4	0.3	0.2	19	20	0.6
6	Oct-01	JUN EFF	18	1.1	0.6	0.6	12	13	1.6
6	Oct-97	JUN ELL	6	0.3	0.2	0.2	24	25	0.5
6	Oct-99	JUN ELL	2	0.1	0.1	0.1	27	26	0.2
6	May-00	JUN ELL	109	4.8	1.9	1.3	6	11	6.1
6	Oct-00	JUN ELL	3	0.2	0.0	0.0	28	32	0.2
6	Jun-01	JUN ELL	89	4.1	3.1	2.2	6	7	6.3
6	Oct-01	JUN ELL	7	0.4	0.1	0.1	20	24	0.5
6	May-00	JUN MAR	2	0.1	0.1	0.1	37	34	0.2
6	Jun-01	JUN MAR	9	0.4	0.3	0.2	19	20	0.6

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
6	Oct-01	JUN MAR	1	0.1	0.0	0.0	34	33	0.1
6	Oct-00	JUN MEG	4	0.2	0.1	0.1	25	27	0.3
6	Oct-01	JUN MEG	2	0.1	0.1	0.1	30	26	0.2
6	May-00	JUN SCI	4	0.2	0.1	0.1	34	34	0.2
6	Oct-97	KOS VIR	2	0.1	0.1	0.1	33	31	0.2
6	Oct-97	LEE SP.	6	0.3	0.4	0.3	24	20	0.6
6	Oct-99	LEE SP.	12	0.7	1.2	0.9	15	10	1.6
6	May-00	LEE SP.	22	1.0	1.5	1.0	16	13	2.0
6	Oct-00	LEE SP.	10	0.6	0.6	0.5	17	12	1.1
6	Jun-01	LEE SP.	14	0.6	1.3	0.9	17	12	1.6
6	Oct-01	LEE SP.	15	0.9	1.6	1.5	16	7	2.4
6	May-00	LIL CHI	9	0.4	0.5	0.3	23	19	0.7
6	Oct-00	LIL CHI	3	0.2	0.0	0.0	28	32	0.2
6	Jun-01	LIL CHI	18	0.8	0.4	0.3	15	19	1.1
6	Oct-01	LIL CHI	11	0.7	0.2	0.2	17	19	0.8
6	Oct-99	LUD PAL	8	0.5	0.2	0.2	20	20	0.6
6	May-00	LUD PAL	56	2.5	1.0	0.7	8	15	3.2
6	Jun-01	LUD PAL	3	0.1	0.1	0.1	30	29	0.2
6	Oct-97	LUZ FLU	25	1.4	3.9	3.0	11	7	4.3
6	Oct-99	LUZ FLU	21	1.2	0.6	0.5	13	16	1.7
6	May-00	LUZ FLU	42	1.8	4.3	3.0	11	5	4.8
6	Oct-00	LUZ FLU	4	0.2	0.1	0.1	25	27	0.3
6	May-00	LYC RUB	2	0.1	0.1	0.1	37	34	0.2
6	Oct-97	MIK SCA	19	1.0	0.7	0.5	12	13	1.6
6	Oct-99	MIK SCA	38	2.2	1.7	1.3	8	8	3.6
6	May-00	MIK SCA	55	2.4	3.9	2.7	9	7	5.1
6	Oct-00	MIK SCA	12	0.7	0.3	0.3	14	17	1.0
6	Jun-01	MIK SCA	25	1.2	0.5	0.4	14	17	1.5
6	Oct-01	MIK SCA	4	0.2	0.1	0.1	24	24	0.3
6	May-00	MIM QUA	2	0.1	0.1	0.1	37	34	0.2
6	Oct-97	MUR KEI	119	6.5	6.9	5.3	6	5	11.8
6	May-00	MUR KEI	30	1.3	1.0	0.7	15	14	2.0
6	Oct-00	MUR KEI	3	0.2	0.1	0.1	28	29	0.3
6	Jun-01	MUR KEI	46	2.1	0.9	0.7	9	15	2.8
6	Oct-97	MYR CER	40	2.2	4.7	3.6	8	6	5.8
6	Oct-99	MYR CER	48	2.8	5.8	4.5	7	5	7.3
6	May-00	MYR CER	39	1.7	4.2	2.9	13	6	4.6
6	Oct-00	MYR CER	29	1.8	2.5	2.1	9	6	3.9
6	Jun-01	MYR CER	31	1.4	3.0	2.1	13	8	3.5
6	Oct-01	MYR CER	36	2.1	2.7	2.5	6	6	4.7
6	Oct-97	OSM REG	42	2.3	3.9	3.0	7	7	5.3
6	Oct-99	OSM REG	34	2.0	3.1	2.4	10	6	4.4
6	May-00	OSM REG	34	1.5	3.9	2.7	14	7	4.2
6	Oct-00	OSM REG	35	2.2	4.2	3.6	7	5	5.7
6	Jun-01	OSM REG	36	1.7	4.5	3.2	11	5	4.8
6	Oct-01	OSM REG	37	2.2	4.1	3.8	5	5	6.0
6	May-00	PAN DIC	7	0.3	0.2	0.1	28	26	0.4

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
6	Oct-97	PAN RIG	18	1.0	0.6	0.5	13	14	1.4
6	Oct-99	PAN RIG	35	2.1	1.0	0.8	9	11	2.8
6	Oct-00	PAN RIG	25	1.6	0.7	0.6	11	11	2.2
6	Oct-01	PAN RIG	32	1.9	0.8	0.7	8	10	2.6
6	Oct-00	PAS URV	6	0.4	0.4	0.3	22	13	0.7
6	Jun-01	PAS URV	5	0.2	0.2	0.1	27	23	0.4
6	Oct-01	PAS URV	4	0.2	0.1	0.1	24	26	0.3
6	Oct-97	PER PAL	4	0.2	0.2	0.2	28	27	0.4
6	Oct-99	PER PAL	6	0.4	0.2	0.2	22	20	0.5
6	Oct-00	PER PAL	2	0.1	0.1	0.1	32	29	0.2
6	Oct-01	PER PAL	4	0.2	0.2	0.2	24	20	0.4
6	Oct-97	PLU ODO	6	0.3	0.2	0.2	24	24	0.5
6	Oct-99	PLU ODO	7	0.4	0.2	0.2	21	19	0.6
6	May-00	PLU ODO	10	0.4	0.4	0.3	21	20	0.7
6	Oct-00	PLU ODO	30	1.9	1.1	1.0	8	9	2.8
6	Jun-01	PLU ODO	43	2.0	1.2	0.8	10	13	2.8
6	Oct-01	PLU ODO	34	2.0	1.0	1.0	7	9	3.0
6	May-00	POL ARI	8	0.4	0.3	0.2	25	22	0.6
6	Oct-00	POL ARI	6	0.4	0.2	0.2	22	20	0.6
6	Jun-01	POL ARI	17	0.8	0.6	0.4	16	16	1.2
6	Oct-01	POL ARI	7	0.4	0.2	0.2	20	20	0.6
6	Oct-97	POL PUN	144	7.9	3.5	2.7	5	9	10.5
6	Oct-99	POL PUN	90	5.3	2.6	2.0	5	7	7.3
6	May-00	POL PUN	54	2.4	1.6	1.1	10	12	3.5
6	Oct-00	POL PUN	56	3.5	1.6	1.4	5	8	4.9
6	Jun-01	POL PUN	52	2.4	2.3	1.6	8	9	4.0
6	Oct-01	POL PUN	32	1.9	1.2	1.1	8	8	3.0
6	May-00	PON COR	5	0.2	0.2	0.1	30	26	0.4
6	Jun-01	PON COR	9	0.4	0.2	0.1	19	23	0.6
6	Jun-01	PTI CAP	1	0.0	0.0	0.0	36	36	0.1
6	May-00	PTI COS	13	0.6	0.2	0.2	19	25	0.7
6	May-00	QUE LAU	5	0.2	0.2	0.1	30	26	0.4
6	Oct-00	QUE LAU	4	0.2	0.2	0.2	25	25	0.4
6	Jun-01	QUE LAU	3	0.1	0.1	0.1	30	29	0.2
6	Oct-01	QUE LAU	8	0.5	0.5	0.5	19	16	0.9
6	Oct-97	RHY MCC	3	0.2	0.1	0.1	31	31	0.2
6	May-00	RUM VER	5	0.2	0.2	0.1	30	26	0.4
6	Oct-97	SAG LAN	2	0.1	0.1	0.1	33	31	0.2
6	Oct-99	SAG LAN	2	0.1	0.1	0.1	27	26	0.2
6	May-00	SAG LAN	40	1.8	1.0	0.7	12	15	2.5
6	Jun-01	SAG LAN	35	1.6	1.1	0.8	12	14	2.4
6	Oct-97	SCI TAB	238	13.0	8.3	6.3	3	4	19.3
6	Oct-99	SCI TAB	182	10.7	7.7	6.0	4	4	16.7
6	May-00	SCI TAB	344	15.1	15.3	10.6	3	4	25.7
6	Oct-00	SCI TAB	269	16.7	10.1	8.6	3	3	25.3
6	Jun-01	SCI TAB	410	18.9	23.2	16.4	1	3	35.3
6	Oct-01	SCI TAB	380	22.5	15.4	14.4	2	3	36.9

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
6	Oct-97	SOL SEM	4	0.2	0.2	0.2	28	27	0.4
6	Oct-99	SOL SEM	5	0.3	0.2	0.2	23	20	0.4
6	Oct-00	SOL SEM	7	0.4	0.2	0.2	20	20	0.6
6	Jun-01	SOL SEM	6	0.3	0.2	0.1	26	23	0.4
6	Oct-01	SOL SEM	11	0.7	0.4	0.4	17	17	1.0
6	Oct-97	TAX DIS	3	0.2	0.1	0.1	31	31	0.2
6	Oct-99	TAX DIS	5	0.3	0.2	0.2	23	20	0.4
6	Oct-01	TAX DIS	2	0.1	0.0	0.0	30	33	0.1
6	May-00	TOX RAD	14	0.6	0.3	0.2	18	22	0.8
6	Jun-01	TOX RAD	8	0.4	0.2	0.1	22	23	0.5
6	Oct-01	TOX RAD	1	0.1	0.0	0.0	34	33	0.1
6	Oct-97	TYP ANG	4	0.2	0.2	0.2	28	27	0.4
6	Oct-99	TYP ANG	12	0.7	0.1	0.1	15	24	0.8
6	May-00	TYP ANG	2	0.1	0.1	0.1	37	33	0.2
6	Oct-00	TYP ANG	11	0.7	0.3	0.3	16	16	1.0
6	Jun-01	TYP ANG	8	0.4	0.3	0.2	22	20	0.6
6	Oct-01	TYP ANG	23	1.4	0.6	0.6	10	13	1.9
6	Jun-01	UNK GRA	2	0.1	0.1	0.1	34	29	0.2
6	May-00	VIG LUT	3	0.1	0.1	0.1	35	34	0.2
6	Oct-97	XYR IRI	18	1.0	0.4	0.3	13	17	1.3
6	Oct-99	XYR IRI	2	0.1	0.0	0.0	27	28	0.1
6	Oct-97	ZIZ AQU	31	1.7	0.8	0.6	9	11	2.3
6	Oct-99	ZIZ AQU	5	0.3	0.1	0.1	23	25	0.4
6	Oct-00	ZIZ AQU	26	1.6	1.8	1.5	10	7	3.2
6	Oct-01	ZIZ AQU	17	1.0	0.7	0.7	14	11	1.7
6	Oct-97	ZIZ MIL	369	20.2	38.7	29.6	2	2	49.8
6	Oct-99	ZIZ MIL	384	22.6	42.1	32.7	2	1	55.3
6	May-00	ZIZ MIL	356	15.7	32.4	22.5	2	2	38.1
6	Oct-00	ZIZ MIL	369	22.9	40.7	34.6	2	1	57.6
6	Jun-01	ZIZ MIL	351	16.2	26.7	18.9	3	2	35.0
6	Oct-01	ZIZ MIL	359	21.3	26.1	24.4	3	2	45.7
7	Oct-99	ALT PHI	8	0.4	0.2	0.1	17	17	0.6
7	May-00	ALT PHI	15	0.7	1.3	0.7	17	14	1.3
7	Oct-00	ALT PHI	13	0.7	0.2	0.2	15	15	0.9
7	Jun-01	ALT PHI	15	0.7	1.2	0.7	18	14	1.4
7	Oct-01	ALT PHI	12	0.8	0.2	0.2	14	15	1.0
7	Oct-97	AMA CAN	6	0.4	0.3	0.2	14	13	0.6
7	Oct-99	AMA CAN	13	0.7	0.4	0.3	15	14	1.0
7	May-00	AMA CAN	10	0.4	0.2	0.1	18	18	0.5
7	Oct-00	AMA CAN	44	2.5	1.5	1.4	11	11	3.9
7	Jun-01	AMA CAN	89	4.3	3.6	2.1	10	10	6.4
7	Oct-01	AMA CAN	116	7.5	3.7	4.4	4	9	11.8
7	Oct-97	AST ELL	138	8.2	17.0	12.7	5	4	20.9
7	Oct-99	AST ELL	166	8.8	20.8	15.4	6	5	24.2
7	May-00	AST ELL	129	5.6	13.5	7.0	7	5	12.7
7	Oct-00	AST ELL	131	7.4	8.7	8.1	5	6	15.5
7	Jun-01	AST ELL	90	4.4	6.1	3.6	9	9	7.9

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
7	Oct-01	AST ELL	50	3.2	5.4	6.4	11	4	9.6
7	Oct-97	AST NOV	33	1.9	3.3	2.5	8	8	4.4
7	Oct-99	AST NOV	15	0.8	0.4	0.3	14	15	1.1
7	May-00	AST NOV	88	3.8	3.4	1.8	8	11	5.6
7	Jun-01	AST NOV	98	4.7	9.5	5.6	7	7	10.3
7	Oct-00	AST TEN	8	0.5	0.2	0.2	17	15	0.6
7	Jun-01	AST TEN	23	1.1	0.6	0.4	14	17	1.5
7	Oct-01	AST TEN	44	2.8	2.6	3.1	12	11	5.9
7	Oct-97	BID LAE	382	22.6	39.1	29.3	1	1	51.8
7	Oct-99	BID LAE	213	11.3	26.4	19.5	4	1	30.8
7	May-00	BID LAE	203	8.9	27.6	14.3	5	3	23.2
7	Oct-00	BID LAE	128	7.3	12.4	11.5	6	3	18.8
7	Jun-01	BID LAE	21	1.0	1.5	0.9	15	12	1.9
7	Oct-01	BID LAE	97	6.3	4.1	4.8	8	6	11.1
7	Oct-97	BOL AST	2	0.1	0.0	0.0	15	17	0.1
7	Oct-99	BOL AST	23	1.2	0.5	0.4	12	13	1.6
7	May-00	BOL AST	10	0.4	0.2	0.1	18	19	0.5
7	Oct-00	BOL AST	23	1.3	0.5	0.5	13	13	1.8
7	Jun-01	BOL AST	24	1.2	1.3	0.8	12	13	1.9
7	Oct-01	BOL AST	12	0.8	0.4	0.5	14	14	1.3
7	Oct-97	CIC MAC	33	1.9	3.0	2.2	8	9	4.2
7	May-00	CIC MAC	19	0.8	0.7	0.4	15	16	1.2
7	Jun-01	CIC MAC	5	0.2	0.5	0.3	21	18	0.5
7	Oct-97	ELE CEL	26	1.5	3.7	2.8	10	7	4.3
7	Oct-99	ELE FAL	20	1.1	1.8	1.3	13	9	2.4
7	May-00	ELE FAL	27	1.2	1.2	0.6	14	15	1.8
7	Oct-00	ELE FAL	18	1.0	0.2	0.2	14	15	1.2
7	Jun-01	ELE FAL	14	0.7	0.2	0.1	19	21	0.8
7	Oct-97	LIL CHI	2	0.1	0.1	0.1	15	15	0.2
7	Oct-99	LIL CHI	71	3.8	1.0	0.7	8	11	4.5
7	May-00	LIL CHI	57	2.5	3.7	1.9	10	10	4.4
7	Oct-00	LIL CHI	60	3.4	2.3	2.1	10	10	5.5
7	Jun-01	LIL CHI	24	1.2	0.4	0.2	12	20	1.4
7	Oct-97	PEL VIR	93	5.5	2.9	2.2	6	10	7.7
7	Oct-99	PEL VIR	172	9.1	4.2	3.1	5	7	12.2
7	May-00	PEL VIR	472	20.6	63.4	32.9	1	1	53.6
7	Oct-00	PEL VIR	155	8.8	3.4	3.1	4	8	11.9
7	Jun-01	PEL VIR	394	19.1	40.9	23.9	1	2	43.0
7	Oct-01	PEL VIR	99	6.4	2.6	3.1	7	10	9.5
7	Oct-99	PLU ODO	11	0.6	0.3	0.2	16	16	0.8
7	Oct-00	PLU ODO	12	0.7	0.3	0.3	16	14	1.0
7	Jun-01	PLU ODO	13	0.6	0.5	0.3	20	18	0.9
7	Oct-01	PLU ODO	17	1.1	0.7	0.8	13	13	1.9
7	Oct-97	POL PUN	301	17.8	19.9	14.9	3	3	32.7
7	Oct-99	POL PUN	315	16.7	21.6	16.0	2	4	32.7
7	May-00	POL PUN	278	12.2	16.5	8.6	3	4	20.7
7	Oct-00	POL PUN	198	11.2	10.0	9.3	3	4	20.5

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
7	Jun-01	POL PUN	173	8.4	14.1	8.2	5	3	16.6
7	Oct-01	POL PUN	114	7.3	4.0	4.7	5	8	12.1
7	Oct-99	PON COR	8	0.4	0.2	0.1	17	17	0.6
7	Oct-01	PON COR	3	0.2	0.1	0.1	16	16	0.3
7	Oct-97	PTI COS	17	1.0	0.6	0.4	12	12	1.5
7	Oct-99	PTI COS	3	0.2	0.1	0.1	20	20	0.2
7	May-00	RUM VER	4	0.2	0.1	0.1	20	20	0.2
7	Oct-97	SAG LAN	2	0.1	0.1	0.1	15	15	0.2
7	Oct-99	SAG LAN	7	0.4	0.2	0.1	19	17	0.5
7	May-00	SAG LAN	38	1.7	1.4	0.7	13	13	2.4
7	Jun-01	SAG LAN	60	2.9	1.8	1.1	11	11	4.0
7	Oct-97	SCI ROB	11	0.6	0.3	0.2	13	13	0.9
7	Oct-99	SCI ROB	84	4.5	3.9	2.9	7	8	7.3
7	May-00	SCI ROB	148	6.5	3.9	2.0	6	9	8.5
7	Oct-00	SCI ROB	103	5.8	3.2	3.0	7	9	8.8
7	Jun-01	SCI ROB	190	9.2	12.7	7.4	4	4	16.6
7	Oct-01	SCI ROB	135	8.7	4.1	4.8	3	7	13.5
7	Oct-97	SCI TAB	271	16.0	13.5	10.1	4	5	26.1
7	Oct-99	SCI TAB	286	15.2	22.7	16.8	3	2	31.9
7	May-00	SCI TAB	365	16.0	33.9	17.6	2	2	33.6
7	Oct-00	SCI TAB	348	19.8	29.4	27.4	1	1	47.1
7	Jun-01	SCI TAB	381	18.4	42.6	24.9	2	1	43.3
7	Oct-01	SCI TAB	385	24.8	29.6	34.9	1	1	59.7
7	May-00	SIU SUA	55	2.4	1.8	0.9	11	12	3.3
7	Jun-01	SIU SUA	16	0.8	0.7	0.4	17	15	1.2
7	Oct-97	SPA ALT	2	0.1	0.0	0.0	15	17	0.1
7	Oct-99	SPA ALT	24	1.3	0.7	0.5	11	12	1.8
7	May-00	SPA ALT	18	0.8	0.6	0.3	16	17	1.1
7	Oct-00	SPA ALT	31	1.8	1.1	1.0	12	12	2.8
7	Jun-01	SPA ALT	20	1.0	0.7	0.4	16	15	1.4
7	Oct-01	SPA ALT	58	3.7	2.3	2.7	10	12	6.4
7	Oct-97	SPA CYN	50	3.0	5.3	4.0	7	6	6.9
7	Oct-99	SPA CYN	60	3.2	5.7	4.2	9	6	7.4
7	May-00	SPA CYN	52	2.3	6.4	3.3	12	7	5.6
7	Oct-00	SPA CYN	74	4.2	8.8	8.2	9	5	12.4
7	Jun-01	SPA CYN	94	4.5	12.7	7.4	8	4	12.0
7	Oct-01	SPA CYN	88	5.7	9.9	11.7	9	3	17.3
7	Oct-97	TYP ANG	22	1.3	0.7	0.5	11	11	1.8
7	Oct-99	TYP ANG	56	3.0	1.7	1.3	10	10	4.2
7	May-00	TYP ANG	77	3.4	3.9	2.0	9	8	5.4
7	Oct-00	TYP ANG	89	5.1	3.6	3.4	8	7	8.4
7	Jun-01	TYP ANG	108	5.2	9.4	5.5	6	8	10.7
7	Oct-01	TYP ANG	100	6.4	5.0	5.9	6	5	12.4
7	Oct-97	ZIZ MIL	302	17.8	23.8	17.8	2	2	35.6
7	Oct-99	ZIZ MIL	332	17.6	22.5	16.6	1	3	34.2
7	May-00	ZIZ MIL	223	9.7	8.7	4.5	4	6	14.3
7	Oct-00	ZIZ MIL	327	18.6	21.6	20.1	2	2	38.7

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
7	Jun-01	ZIZ MIL	215	10.4	9.9	5.8	3	6	16.2
7	Oct-01	ZIZ MIL	222	14.3	10.0	11.8	2	2	26.1
8	Oct-99	ACE RUB	1	0.0	0.0	0.0	56	55	0.0
8	Oct-97	AGA PUR	150	5.8	2.4	1.7	5	8	7.5
8	Oct-99	AGA PUR	104	3.7	1.9	1.3	8	13	5.0
8	May-00	AGA PUR	202	4.8	7.4	3.0	7	8	7.9
8	Oct-00	AGA PUR	134	3.8	3.6	1.6	8	10	5.4
8	Jun-01	AGA PUR	83	2.2	2.1	1.1	16	15	3.3
8	Oct-01	AGA PUR	98	2.8	2.4	1.2	13	14	4.0
8	Oct-01	AGR PER	6	0.2	0.1	0.1	46	54	0.2
8	Oct-97	ALN SER	129	5.0	17.7	12.5	7	3	17.5
8	Oct-99	ALN SER	131	4.7	17.4	11.4	6	3	16.1
8	May-00	ALN SER	125	3.0	20.1	8.3	11	3	11.3
8	Oct-00	ALN SER	121	3.4	13.6	6.2	9	5	9.6
8	Jun-01	ALN SER	116	3.1	15.0	7.5	11	3	10.6
8	Oct-01	ALN SER	119	3.4	11.9	6.3	9	4	9.7
8	Oct-99	AMA CAN	7	0.2	0.2	0.1	41	40	0.4
8	May-00	AMA CAN	13	0.3	0.3	0.1	43	46	0.4
8	Jun-01	AMA CAN	8	0.2	0.2	0.1	45	44	0.3
8	Oct-01	AMA CAN	6	0.2	0.1	0.1	46	57	0.2
8	Oct-00	AND GLO	2	0.1	0.1	0.0	54	52	0.1
8	Oct-97	API AME	16	0.6	0.5	0.4	28	27	1.0
8	May-00	API AME	40	1.0	4.5	1.9	26	13	2.8
8	Oct-00	API AME	19	0.5	0.4	0.2	34	35	0.7
8	Jun-01	API AME	34	0.9	0.8	0.4	22	28	1.3
8	Oct-97	ART HIS	12	0.5	0.3	0.2	31	32	0.7
8	Oct-99	ART HIS	57	2.0	3.0	2.0	17	7	4.0
8	May-00	ART HIS	27	0.6	0.8	0.3	33	34	1.0
8	Oct-00	ART HIS	115	3.2	9.1	4.1	10	6	7.4
8	Jun-01	ART HIS	9	0.2	0.2	0.1	44	42	0.3
8	Oct-01	ART HIS	96	2.7	3.7	2.0	14	9	4.7
8	Oct-97	AST ELL	130	5.0	4.5	3.2	6	6	8.2
8	Oct-99	AST ELL	172	6.1	4.2	2.8	5	6	8.9
8	May-00	AST ELL	188	4.5	4.9	2.0	8	11	6.5
8	Oct-00	AST ELL	148	4.2	4.9	2.2	6	8	6.4
8	Jun-01	AST ELL	192	5.2	4.4	2.2	8	9	7.4
8	Oct-01	AST ELL	153	4.3	3.5	1.9	6	10	6.2
8	Oct-97	AST NOV	4	0.2	0.2	0.1	43	39	0.3
8	Oct-00	AST NOV	5	0.1	0.2	0.1	48	44	0.2
8	Oct-97	AST SUB	73	2.8	1.4	1.0	11	13	3.8
8	Oct-97	BAC HAL	2	0.1	0.1	0.1	48	44	0.1
8	May-00	BAC HAL	3	0.1	0.2	0.1	53	48	0.2
8	Oct-00	BAC HAL	1	0.0	0.0	0.0	59	59	0.0
8	Oct-01	BAC HAL	2	0.1	0.1	0.1	60	57	0.1
8	Oct-97	BID LAE	22	0.8	0.6	0.4	27	24	1.3
8	Oct-99	BID LAE	51	1.8	1.8	1.2	19	15	3.0
8	May-00	BID LAE	72	1.7	1.8	0.7	17	21	2.5

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
8	Oct-00	BID LAE	37	1.0	0.9	0.4	24	25	1.5
8	Jun-01	BID LAE	18	0.5	0.9	0.4	32	26	0.9
8	Oct-01	BID LAE	28	0.8	0.8	0.4	26	27	1.2
8	May-00	BID MIT	186	4.5	3.3	1.3	9	18	5.8
8	Oct-00	BID MIT	196	5.5	5.5	2.5	5	7	8.0
8	Jun-01	BID MIT	201	5.4	4.0	2.0	7	12	7.4
8	Oct-01	BID MIT	140	4.0	3.0	1.6	7	12	5.6
8	May-00	BOE CYL	1	0.0	0.0	0.0	59	57	0.0
8	Oct-97	BOL AST	11	0.4	0.3	0.2	32	32	0.6
8	Oct-01	BOL AST	5	0.1	0.2	0.1	51	47	0.2
8	Oct-97	CAL SEP	25	1.0	0.4	0.3	26	29	1.2
8	Oct-00	CAR ALA	105	3.0	1.8	0.8	11	22	3.8
8	Jun-01	CAR ALA	30	0.8	0.9	0.4	24	26	1.3
8	May-00	CAR COM	30	0.7	0.9	0.4	30	33	1.1
8	Oct-00	CAR COM	8	0.2	0.3	0.1	45	39	0.4
8	Jun-01	CAR COM	14	0.4	0.5	0.2	35	32	0.6
8	Oct-01	CAR COM	10	0.3	0.3	0.2	41	42	0.5
8	Oct-99	CAR LON	42	1.5	1.0	0.7	22	25	2.2
8	May-00	CAR LON	57	1.4	1.0	0.4	19	32	1.8
8	Jun-01	CAR LON	140	3.8	2.3	1.2	10	14	4.9
8	Oct-01	CAR LON	92	2.6	1.7	0.9	17	21	3.5
8	Jun-01	CAR LUP	10	0.3	0.5	0.2	42	32	0.5
8	Oct-01	CAR LUP	10	0.3	0.3	0.2	41	43	0.4
8	Oct-00	CAR SP1	2	0.1	0.0	0.0	54	56	0.1
8	Oct-97	CHA FAS	41	1.6	1.1	0.8	18	18	2.4
8	Oct-99	CHA FAS	67	2.4	1.8	1.2	13	16	3.6
8	May-00	CHA FAS	55	1.3	1.2	0.5	20	26	1.8
8	Oct-00	CHA FAS	74	2.1	2.3	1.1	15	18	3.1
8	Jun-01	CHA FAS	90	2.4	1.8	0.9	15	17	3.3
8	Oct-01	CHA FAS	108	3.1	2.6	1.4	10	13	4.4
8	Oct-97	CIC MAC	33	1.3	1.0	0.7	21	21	2.0
8	Oct-99	CIC MAC	68	2.4	2.0	1.3	11	12	3.7
8	May-00	CIC MAC	267	6.4	9.8	4.0	5	6	10.4
8	Oct-00	CIC MAC	53	1.5	3.0	1.3	19	14	2.8
8	Jun-01	CIC MAC	228	6.1	7.4	3.7	6	5	9.8
8	Oct-01	CIC MAC	23	0.6	0.7	0.4	28	29	1.0
8	May-00	CLE CRI	12	0.3	0.2	0.1	44	48	0.4
8	Jun-01	CLE CRI	2	0.1	0.1	0.0	58	50	0.1
8	Oct-97	CYP HAS	98	3.8	1.9	1.4	10	11	5.1
8	Oct-99	CYP HAS	59	2.1	1.3	0.9	16	19	3.0
8	May-00	CYP HAS	76	1.8	1.8	0.7	16	21	2.6
8	Oct-00	CYP HAS	143	4.0	3.0	1.4	7	13	5.4
8	Jun-01	CYP HAS	30	0.8	1.0	0.5	24	24	1.3
8	Oct-01	CYP HAS	94	2.7	2.1	1.1	16	17	3.7
8	Oct-97	CYP LAN	1	0.0	0.0	0.0	54	56	0.0
8	Oct-99	CYP LAN	22	0.8	0.7	0.5	31	29	1.3
8	Oct-00	CYP LAN	2	0.1	0.0	0.0	54	59	0.1

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
8	Oct-01	CYP LAN	34	1.0	0.8	0.4	25	28	1.4
8	Oct-97	CYP STE	35	1.3	1.0	0.7	19	19	2.1
8	Oct-00	CYP STE	16	0.5	0.3	0.1	38	41	0.6
8	Oct-01	CYP STE	13	0.4	0.5	0.3	37	34	0.6
8	Oct-01	CYP VIR	2	0.1	0.1	0.1	60	57	0.1
8	Oct-97	DUL ARU	105	4.0	3.2	2.3	9	7	6.3
8	Oct-99	DUL ARU	33	1.2	1.2	0.8	24	20	2.0
8	May-00	DUL ARU	23	0.6	0.5	0.2	34	40	0.8
8	Oct-00	DUL ARU	26	0.7	0.6	0.3	27	29	1.0
8	Jun-01	DUL ARU	2	0.1	0.1	0.0	58	50	0.1
8	Oct-01	DUL ARU	3	0.1	0.0	0.0	57	67	0.1
8	Oct-97	ELE CEL	29	1.1	0.5	0.4	25	27	1.5
8	Oct-99	ELE CEL	72	2.6	2.3	1.5	10	9	4.1
8	May-00	ELE CEL	3	0.1	0.1	0.0	53	54	0.1
8	Oct-00	ELE CEL	9	0.3	0.3	0.1	44	39	0.4
8	Oct-97	ELE FAL	317	12.2	45.6	32.3	1	1	44.5
8	Oct-99	ELE FAL	333	11.9	48.1	31.5	1	1	43.4
8	May-00	ELE FAL	357	8.5	54.7	22.5	1	1	31.1
8	Oct-00	ELE FAL	355	10.0	52.2	23.7	2	1'	33.7
8	Jun-01	ELE FAL	348	9.3	51.6	25.8	2	1	35.1
8	Oct-01	ELE FAL	342	9.7	43.0	22.7	2	1	32.4
8	Oct-99	ELE QUA	11	0.4	0.2	0.1	34	40	0.5
8	May-00	ELE QUA	30	0.7	0.5	0.2	30	39	0.9
8	Jun-01	ELE QUA	17	0.5	0.3	0.1	33	39	0.6
8	Oct-01	ELE QUA	3	0.1	2.0	1.1	57	19	1.1
8	Oct-97	ERA ELL	2	0.1	0.1	0.1	48	44	0.1
8	Oct-00	ERA ELL	2	0.1	0.1	0.0	54	52	0.1
8	May-00	ERY AQU	10	0.2	0.5	0.2	46	41	0.4
8	Oct-97	FUI BRE	7	0.3	0.2	0.1	36	38	0.4
8	Oct-99	FUI BRE	63	2.2	1.2	0.8	14	20	3.0
8	May-00	FUI BRE	21	0.5	0.5	0.2	37	42	0.7
8	Oct-00	FUI BRE	101	2.8	2.4	1.1	12	15	3.9
8	Jun-01	FUI BRE	34	0.9	0.7	0.4	22	29	1.3
8	Oct-01	FUI BRE	76	2.1	2.3	1.2	18	15	3.4
8	Oct-97	GAL OBT	53	2.0	1.0	0.7	15	20	2.7
8	Oct-99	GAL OBT	77	2.7	2.9	1.9	9	8	4.6
8	May-00	GAL OBT	120	2.9	3.4	1.4	12	16	4.3
8	Oct-00	GAL OBT	74	2.1	4.0	1.8	15	9	3.9
8	Jun-01	GAL OBT	113	3.0	2.6	1.3	12	13	4.3
8	Oct-01	GAL OBT	95	2.7	2.2	1.2	15	16	3.9
8	May-00	HAB REP	2	0.0	0.0	0.0	55	57	0.1
8	Oct-00	HAB REP	1	0.0	0.0	0.0	59	59	0.0
8	Oct-01	HAB REP	1	0.0	0.0	0.0	71	71	0.0
8	Oct-01	HAM VIR	1	0.0	0.0	0.0	71	71	0.0
8	Jun-01	HYD UMB	11	0.3	0.2	0.1	40	44	0.4
8	Oct-01	HYD UMB	10	0.3	0.2	0.1	41	47	0.4
8	Oct-97	HYP MUT	13	0.5	0.3	0.2	30	31	0.7

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
8	Oct-99	HYP MUT	14	0.5	0.5	0.3	33	31	0.8
8	May-00	HYP MUT	30	0.7	0.7	0.3	30	36	1.0
8	Jun-01	HYP MUT	3	0.1	0.1	0.0	54	50	0.1
8	Oct-01	HYP MUT	18	0.5	0.6	0.3	31	31	0.8
8	Oct-01	HYP SP.	1	0.0	0.0	0.0	71	71	0.0
8	Oct-97	IRI VIR	43	1.7	0.9	0.7	17	22	2.3
8	Oct-99	IRI VIR	61	2.2	1.1	0.7	15	23	2.9
8	May-00	IRI VIR	138	3.3	4.9	2.0	10	10	5.3
8	Oct-00	IRI VIR	84	2.4	1.6	0.7	14	23	3.1
8	Jun-01	IRI VIR	164	4.4	4.7	2.4	9	8	6.8
8	Oct-01	IRI VIR	101	2.9	2.0	1.1	12	18	3.9
8	Jun-01	JUN EFF	4	0.1	0.1	0.0	53	50	0.2
8	Oct-01	JUN EFF	2	0.1	0.1	0.1	60	57	0.1
8	Oct-97	JUN ELL	3	0.1	0.1	0.1	45	43	0.2
8	Oct-99	JUN ELL	8	0.3	0.3	0.2	39	35	0.5
8	May-00	JUN ELL	89	2.1	2.2	0.9	13	19	3.0
8	Jun-01	JUN ELL	110	3.0	2.0	1.0	13	16	4.0
8	Oct-01	JUN ELL	13	0.4	0.3	0.2	37	41	0.5
8	Oct-99	JUN MAR	3	0.1	0.1	0.1	50	48	0.2
8	May-00	JUN MAR	53	1.3	1.1	0.4	23	28	1.7
8	Oct-00	JUN MAR	4	0.1	0.0	0.0	51	55	0.1
8	Jun-01	JUN MAR	8	0.2	0.1	0.0	45	50	0.3
8	Oct-01	JUN MAR	5	0.1	0.2	0.1	51	46	0.3
8	Oct-00	JUN MEG	7	0.2	0.2	0.1	46	43	0.3
8	Oct-01	JUN MEG	2	0.1	0.0	0.0	60	67	0.1
8	Jun-01	JUN POL	8	0.2	0.2	0.1	45	42	0.3
8	Oct-01	JUN SCI	4	0.1	0.2	0.1	54	47	0.2
8	Oct-97	LEE SP.	208	8.0	5.6	4.0	3	5	12.0
8	Oct-99	LEE SP.	222	7.9	12.3	8.1	3	4	16.0
8	May-00	LEE SP.	293	7.0	9.8	4.0	4	6	11.0
8	Oct-00	LEE SP.	329	9.3	19.3	8.8	3	4	18.0
8	Jun-01	LEE SP.	233	6.3	4.3	2.2	5	10	8.4
8	Oct-01	LEE SP.	255	7.2	10.6	5.6	4	5	12.8
8	Oct-00	LOB CAR	1	0.0	0.0	0.0	59	59	0.0
8	Oct-97	LOB GLA	1	0.0	0.1	0.1	54	44	0.1
8	May-00	LOB GLA	2	0.0	0.0	0.0	55	57	0.1
8	Oct-00	LOB GLA	22	0.6	0.3	0.2	31	36	0.8
8	Oct-01	LOB GLA	18	0.5	0.3	0.2	31	45	0.7
8	Jun-01	LON JAP	3	0.1	0.1	0.0	54	50	0.1
8	Oct-01	LON JAP	2	0.1	0.1	0.1	60	57	0.1
8	Oct-97	LUD DEC	7	0.3	0.2	0.1	36	39	0.4
8	Oct-99	LUD DEC	4	0.1	0.2	0.1	48	40	0.3
8	Oct-00	LUD DEC	1	0.0	0.1	0.0	59	52	0.1
8	May-00	LUD LEP	35	0.8	1.0	0.4	29	31	1.2
8	Oct-00	LUD LEP	21	0.6	0.5	0.2	32	31	0.8
8	Jun-01	LUD LEP	2	0.1	0.1	0.0	58	50	0.1
8	Oct-01	LUD LEP	41	1.2	1.3	0.7	21	23	1.9

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
8	Oct-01	LUD OCT	2	0.1	0.1	0.1	60	57	0.1
8	Oct-01	LUD PAL	4	0.1	0.2	0.1	54	47	0.2
8	May-00	LUD PIL	47	1.1	1.8	0.7	24	21	1.9
8	Oct-00	LUD PIL	24	0.7	0.9	0.4	29	27	1.1
8	Jun-01	LUD PIL	47	1.3	1.5	0.8	17	20	2.0
8	Oct-01	LUD PIL	52	1.5	1.8	0.9	19	20	2.4
8	Oct-99	LUZ FLU	23	0.8	1.0	0.7	30	26	1.5
8	May-00	LUZ FLU	10	0.2	1.2	0.5	46	27	0.7
8	Oct-00	LUZ FLU	12	0.3	2.0	0.9	41	19	1.2
8	Jun-01	LUZ FLU	20	0.5	1.7	0.8	31	19	1.4
8	Oct-01	LUZ FLU	17	0.5	1.4	0.7	33	22	1.2
8	Oct-97	LYC RUB	8	0.3	0.3	0.2	35	32	0.5
8	Oct-99	LYC RUB	3	0.1	0.1	0.1	50	48	0.2
8	May-00	LYC RUB	1	0.0	0.0	0.0	59	57	0.0
8	Oct-00	LYC RUB	27	0.8	0.6	0.3	26	30	1.0
8	Jun-01	LYC RUB	2	0.1	0.1	0.0	58	50	0.1
8	Oct-01	LYC RUB	17	0.5	0.5	0.3	33	33	0.8
8	Oct-97	MIK SCA	10	0.4	0.3	0.2	33	32	0.6
8	Oct-99	MIK SCA	50	1.8	2.1	1.4	20	11	3.2
8	May-00	MIK SCA	23	0.6	0.5	0.2	34	42	0.8
8	Oct-00	MIK SCA	39	1.1	0.9	0.4	22	26	1.5
8	Jun-01	MIK SCA	22	0.6	0.5	0.2	29	32	0.8
8	Oct-01	MIK SCA	13	0.4	0.4	0.2	37	35	0.6
8	Oct-97	MUR KEI	172	6.6	11.0	7.8	4	4	14.4
8	Oct-99	MUR KEI	123	4.4	6.4	4.2	7	5	8.6
8	May-00	MUR KEI	316	7.6	37.8	15.6	3	2	23.1
8	Oct-00	MUR KEI	370	10.4	42.7	19.4	1	2	29.8
8	Jun-01	MUR KEI	394	10.6	45.2	22.6	1	2	33.2
8	Oct-01	MUR KEI	366	10.3	41.3	21.8	1	2	32.2
8	Oct-97	MYR CER	6	0.2	0.2	0.1	39	39	0.4
8	Oct-99	MYR CER	24	0.9	1.0	0.7	28	26	1.5
8	May-00	MYR CER	20	0.5	1.9	0.8	38	20	1.3
8	Oct-00	MYR CER	24	0.7	1.9	0.9	29	20	1.5
8	Jun-01	MYR CER	23	0.6	1.5	0.7	28	21	1.4
8	Oct-01	MYR CER	27	0.8	1.3	0.7	27	24	1.4
8	Oct-97	ONO SEN	56	2.2	2.4	1.7	13	9	3.9
8	Oct-99	ONO SEN	44	1.6	1.2	0.8	21	20	2.4
8	May-00	ONO SEN	64	1.5	3.8	1.6	18	15	3.1
8	Oct-00	ONO SEN	41	1.2	1.1	0.5	21	24	1.7
8	Jun-01	ONO SEN	35	0.9	1.4	0.7	21	22	1.6
8	Oct-01	ONO SEN	48	1.4	1.2	0.6	20	25	2.0
8	Oct-99	ORO AQU	2	0.1	0.1	0.1	54	48	0.1
8	Oct-97	OSM REG	31	1.2	2.0	1.4	23	10	2.6
8	Oct-99	OSM REG	28	1.0	1.9	1.2	26	14	2.2
8	May-00	OSM REG	36	0.9	4.5	1.9	27	12	2.7
8	Oct-00	OSM REG	29	0.8	2.3	1.1	25	17	1.9
8	Jun-01	OSM REG	26	0.7	4.0	2.0	27	11	2.7

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
8	Oct-01	OSM REG	36	1.0	3.9	2.1	22	8	3.1
8	Oct-97	PAN HEM	10	0.4	0.3	0.2	33	32	0.6
8	Oct-99	PAN HEM	6	0.2	0.2	0.1	44	40	0.3
8	May-00	PAN HEM	10	0.2	0.2	0.1	46	47	0.3
8	Oct-00	PAN HEM	5	0.1	0.1	0.1	48	49	0.2
8	Jun-01	PAN HEM	2	0.1	0.1	0.0	58	50	0.1
8	Oct-97	PAN RIG	3	0.1	0.1	0.1	45	44	0.2
8	Oct-99	PAN RIG	10	0.4	0.3	0.2	36	35	0.6
8	Oct-00	PAN RIG	13	0.4	0.3	0.1	39	37	0.5
8	Oct-01	PAN RIG	6	0.2	0.1	0.1	46	52	0.2
8	Oct-99	PER PAL	3	0.1	0.1	0.1	50	48	0.2
8	Oct-97	PLU ODO	14	0.5	0.6	0.4	29	24	1.0
8	Oct-99	PLU ODO	6	0.2	0.2	0.1	44	40	0.3
8	Oct-97	POL ARI	32	1.2	0.8	0.6	22	23	1.8
8	Oct-99	POL ARI	5	0.2	0.1	0.1	46	48	0.2
8	May-00	POL ARI	7	0.2	0.1	0.1	50	52	0.2
8	Oct-00	POL ARI	74	2.1	3.3	1.5	15	11	3.6
8	Jun-01	POL ARI	40	1.1	0.9	0.5	19	25	1.5
8	Oct-01	POL ARI	36	1.0	1.0	0.5	22	26	1.6
8	Oct-97	POL PUN	51	2.0	1.3	0.9	16	16	2.9
8	Oct-99	POL PUN	68	2.4	1.7	1.1	11	17	3.5
8	May-00	POL PUN	86	2.1	5.7	2.4	14	9	4.4
8	Oct-00	POL PUN	87	2.5	2.4	1.1	13	16	3.6
8	Jun-01	POL PUN	95	2.6	7.1	3.6	14	6	6.1
8	Oct-01	POL PUN	122	3.4	4.2	2.2	8	7	5.7
8	Oct-97	POL SAG	30	1.2	0.6	0.4	24	24	1.6
8	Oct-99	POL SAG	56	2.0	1.5	1.0	18	18	3.0
8	May-00	POL SAG	54	1.3	3.4	1.4	22	17	2.7
8	Oct-00	POL SAG	39	1.1	0.9	0.4	22	28	1.5
8	Jun-01	POL SAG	3	0.1	0.1	0.0	54	50	0.1
8	Oct-01	POL SAG	9	0.3	0.1	0.1	44	52	0.3
8	Oct-00	PON COR	1	0.0	0.0	0.0	59	59	0.0
8	Jun-01	PON COR	6	0.2	0.4	0.2	49	36	0.4
8	Oct-01	PON COR	5	0.1	0.4	0.2	51	37	0.4
8	May-00	PTI CAP	36	0.9	1.0	0.4	27	30	1.3
8	Jun-01	PTI CAP	14	0.4	0.5	0.2	35	32	0.6
8	Oct-97	PTI COS	63	2.4	1.2	0.9	12	17	3.3
8	Oct-99	PTI COS	15	0.5	0.5	0.3	32	32	0.8
8	May-00	PTI COS	45	1.1	1.0	0.4	25	29	1.5
8	Oct-00	PTI COS	2	0.1	0.0	0.0	54	56	0.1
8	Jun-01	PTI COS	22	0.6	0.6	0.3	29	31	0.9
8	Oct-01	PTI COS	3	0.1	0.1	0.1	57	54	0.1
8	Oct-97	RHY COR	34	1.3	1.3	0.9	20	14	2.2
8	Oct-99	RHY COR	9	0.3	0.2	0.1	37	40	0.5
8	Oct-00	RHY COR	3	0.1	0.1	0.1	52	50	0.1
8	Oct-01	RHY COR	17	0.5	0.4	0.2	33	36	0.7
8	Oct-99	RHY MCC	24	0.9	0.4	0.3	28	33	1.1

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
8	May-00	RHY MCC	81	1.9	1.7	0.7	15	24	2.6
8	Oct-00	RHY MCC	10	0.3	0.2	0.1	42	44	0.4
8	Jun-01	RHY MCC	41	1.1	0.7	0.3	18	30	1.5
8	Oct-01	RHY MCC	35	1.0	0.6	0.3	24	30	1.3
8	Oct-97	RHY MIC	2	0.1	0.1	0.1	48	44	0.1
8	May-00	RHY MIC	8	0.2	0.2	0.1	49	48	0.3
8	Oct-00	RHY MIC	13	0.4	0.2	0.1	39	44	0.5
8	Jun-01	RHY MIC	2	0.1	0.1	0.0	58	50	0.1
8	Oct-01	RHY MIC	6	0.2	0.1	0.1	46	57	0.2
8	Oct-00	RUM VER	1	0.0	0.0	0.0	59	59	0.0
8	Oct-01	RUM VER	2	0.1	0.0	0.0	60	67	0.1
8	Oct-97	SAC GIG	2	0.1	0.1	0.1	48	44	0.1
8	Oct-99	SAC GIG	4	0.1	0.2	0.1	48	40	0.3
8	Oct-00	SAC GIG	1	0.0	0.0	0.0	59	59	0.0
8	Oct-99	SAC IND	25	0.9	0.4	0.3	27	33	1.2
8	Oct-00	SAC IND	51	1.4	3.2	1.5	20	12	2.9
8	Jun-01	SAC IND	5	0.1	0.1	0.0	51	50	0.2
8	Oct-01	SAC IND	108	3.1	7.1	3.8	10	6	6.8
8	Oct-97	SAC STR	6	0.2	0.2	0.1	39	39	0.4
8	Oct-99	SAC STR	5	0.2	0.1	0.1	46	48	0.2
8	Oct-00	SAC STR	18	0.5	0.3	0.1	35	37	0.7
8	Oct-97	SAG FIL	2	0.1	0.1	0.1	48	44	0.1
8	Oct-99	SAG FIL	11	0.4	0.3	0.2	34	35	0.6
8	Oct-01	SAG GRA	2	0.1	0.1	0.1	60	57	0.1
8	Oct-97	SAG LAN	2	0.1	0.1	0.1	48	44	0.1
8	Oct-99	SAG LAN	7	0.2	0.3	0.2	41	35	0.4
8	May-00	SAG LAN	20	0.5	0.6	0.2	38	38	0.7
8	Oct-00	SAG LAN	10	0.3	0.1	0.1	42	48	0.3
8	Jun-01	SAG LAN	40	1.1	1.8	0.9	19	17	2.0
8	Oct-01	SAG LAN	6	0.2	0.2	0.1	46	47	0.3
8	Oct-97	SAG LAT	110	4.2	1.5	1.1	8	12	5.3
8	Oct-99	SAG LAT	177	6.3	2.2	1.4	4	10	7.8
8	May-00	SAG LAT	338	8.1	12.6	5.2	2	5	13.3
8	Oct-00	SAG LAT	70	2.0	1.8	0.8	18	21	2.8
8	Jun-01	SAG LAT	254	6.8	6.0	3.0	3	7	9.8
8	Oct-01	SAG LAT	195	5.5	3.0	1.6	5	11	7.1
8	Jun-01	SAL CAR	3	0.1	0.1	0.0	54	50	0.1
8	Oct-97	SCI CYP	4	0.2	0.1	0.1	43	44	0.2
8	Oct-01	SCI PUN	1	0.0	0.0	0.0	71	71	0.0
8	Oct-97	SCI TAB	6	0.2	0.1	0.1	39	44	0.3
8	Oct-99	SCI TAB	8	0.3	0.2	0.1	39	40	0.4
8	May-00	SCI TAB	12	0.3	0.2	0.1	44	51	0.4
8	Oct-00	SCI TAB	7	0.2	0.1	0.1	46	47	0.3
8	Jun-01	SCI TAB	10	0.3	0.2	0.1	42	49	0.3
8	Oct-01	SCI TAB	4	0.1	0.1	0.1	54	54	0.2
8	May-00	SIU SUA	2	0.0	0.0	0.0	55	56	0.1
8	Oct-97	SOL SEM	3	0.1	0.1	0.1	45	44	0.2

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
8	Oct-99	SOL SEM	9	0.3	0.3	0.2	37	35	0.5
8	Oct-00	SOL SEM	21	0.6	0.4	0.2	32	34	0.8
8	Jun-01	SOL SEM	12	0.3	0.3	0.1	37	39	0.5
8	Oct-01	SOL SEM	8	0.2	0.4	0.2	45	37	0.4
8	Oct-99	TEU CAN	3	0.1	0.1	0.1	50	48	0.2
8	May-00	TEU CAN	16	0.4	0.4	0.2	41	44	0.5
8	Jun-01	TEU CAN	12	0.3	0.3	0.2	37	38	0.5
8	Oct-99	TOX RAD	2	0.1	0.0	0.0	54	55	0.1
8	May-00	TOX RAD	16	0.4	0.4	0.2	41	44	0.5
8	Oct-00	TOX RAD	1	0.0	0.0	0.0	59	59	0.0
8	Jun-01	TOX RAD	6	0.2	0.2	0.1	49	44	0.3
8	May-00	TRI WAL	55	1.3	4.0	1.6	20	14	3.0
8	Oct-00	TRI WAL	25	0.7	0.5	0.2	28	33	0.9
8	Jun-01	TRI WAL	17	0.5	0.4	0.2	33	36	0.7
8	Oct-01	TRI WAL	13	0.4	0.4	0.2	37	37	0.6
8	Oct-97	TYP ANG	1	0.0	0.1	0.1	54	44	0.1
8	Oct-99	TYP ANG	1	0.0	0.0	0.0	56	55	0.0
8	May-00	TYP ANG	2	0.0	0.1	0.0	55	53	0.1
8	Oct-00	TYP ANG	5	0.1	0.1	0.1	48	50	0.2
8	Jun-01	TYP ANG	12	0.3	0.3	0.1	37	39	0.5
8	Oct-01	TYP ANG	19	0.5	0.4	0.2	30	37	0.7
8	Oct-01	UNK HER1	1	0.0	0.0	0.0	71	71	0.0
8	Oct-01	UNK HER2	2	0.1	0.0	0.0	60	67	0.1
8	Oct-01	UNK HER3	1	0.0	0.0	0.0	71	71	0.0
8	Oct-01	UNK HER4	1	0.0	0.0	0.0	71	71	0.0
8	Oct-01	UNK LEG1	2	0.1	0.1	0.1	60	57	0.1
8	Oct-99	VIB DEN	7	0.2	0.8	0.5	41	28	0.8
8	May-00	VIB DEN	6	0.1	0.8	0.3	51	35	0.5
8	Jun-01	VIB DEN	5	0.1	0.1	0.0	51	50	0.2
8	Oct-97	VIB NUD	7	0.3	0.4	0.3	36	29	0.6
8	May-00	VIG LUT	22	0.5	0.6	0.3	36	37	0.8
8	Oct-00	VIG LUT	3	0.1	0.0	0.0	52	56	0.1
8	Jun-01	VIG LUT	7	0.2	0.2	0.1	48	44	0.3
8	Oct-01	VIG LUT	2	0.1	0.1	0.1	60	57	0.1
8	Oct-97	VIO PRI	6	0.2	0.2	0.2	39	37	0.4
8	Oct-99	VIO PRI	31	1.1	0.5	0.3	25	30	1.4
8	May-00	VIO PRI	20	0.5	1.4	0.6	38	25	1.1
8	Oct-00	VIO PRI	17	0.5	0.2	0.1	36	42	0.6
8	Jun-01	VIO PRI	11	0.3	0.2	0.1	40	44	0.4
8	Oct-01	VIO PRI	15	0.4	0.3	0.2	36	43	0.6
8	Oct-97	XYR IRI	54	2.1	1.3	0.9	14	14	3.0
8	Oct-99	XYR IRI	41	1.5	1.0	0.7	23	24	2.1
8	May-00	XYR IRI	4	0.1	0.0	0.0	52	55	0.1
8	Oct-00	XYR IRI	17	0.5	0.5	0.2	36	31	0.7
8	Oct-01	XYR IRI	23	0.6	0.5	0.3	28	32	0.9
8	Jun-01	ZIZ AQU	30	0.8	1.3	0.6	24	23	1.5
8	Oct-97	ZIZ MIL	302	11.6	22.8	16.2	2	2	27.8

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
8	Oct-99	ZIZ MIL	293	10.4	21.3	14.0	2	2	24.4
8	May-00	ZIZ MIL	262	6.3	18.3	7.5	6	4	13.8
8	Oct-00	ZIZ MIL	272	7.7	21.8	9.9	4	3	17.6
8	Jun-01	ZIZ MIL	242	6.5	12.7	6.3	4	4	12.8
8	Oct-01	ZIZ MIL	282	8.0	16.5	8.7	3	3	16.7
9	Oct-97	ACE RUB	2	0.2	0.1	0.1	33	29	0.2
9	Oct-99	ACE RUB	3	0.2	0.1	0.1	23	20	0.3
9	Jun-01	ACE RUB	2	0.1	0.1	0.1	45	42	0.1
9	Oct-97	AGA PUR	3	0.2	0.1	0.1	29	29	0.3
9	Jun-01	AGA PUR	4	0.2	0.2	0.1	36	33	0.3
9	Oct-01	AGA PUR	2	0.1	0.1	0.1	34	33	0.2
9	Oct-97	AMA CAN	5	0.4	0.2	0.2	25	20	0.5
9	May-00	AMA CAN	14	0.6	0.4	0.2	21	26	0.9
9	Oct-00	AMA CAN	61	3.9	3.3	2.3	6	5	6.1
9	Jun-01	AMA CAN	24	1.1	0.6	0.4	16	21	1.4
9	Oct-01	AMA CAN	16	1.0	0.6	0.5	13	12	1.4
9	Oct-99	AMP ARB	6	0.5	0.4	0.3	19	15	0.8
9	May-00	AMP ARB	13	0.6	0.6	0.3	23	22	0.9
9	Oct-00	AMP ARB	9	0.6	0.2	0.2	23	24	0.7
9	Jun-01	AMP ARB	19	0.9	1.0	0.6	19	16	1.4
9	Oct-01	AMP ARB	11	0.7	0.3	0.2	23	20	0.9
9	Jun-01	API AME	17	0.8	0.9	0.5	22	18	1.3
9	Oct-97	AST ELL	136	10.6	8.9	7.0	3	2	17.5
9	Oct-99	AST ELL	120	9.5	8.1	6.3	3	2	15.8
9	May-00	AST ELL	194	8.8	9.4	5.5	3	5	14.3
9	Oct-00	AST ELL	144	9.1	11.2	7.7	3	3	16.8
9	Jun-01	AST ELL	166	7.5	12.9	7.5	4	4	15.0
9	Oct-01	AST ELL	173	10.6	8.5	6.5	3	3	17.0
9	Jun-01	AST LAT	6	0.3	0.2	0.1	34	33	0.4
9	Oct-97	AST NOV	1	0.1	0.1	0.1	36	29	0.2
9	Oct-97	BAC HAL	13	1.0	0.7	0.5	14	12	1.6
9	Oct-99	BAC HAL	26	2.1	1.2	0.9	9	10	3.0
9	May-00	BAC HAL	13	0.6	0.4	0.2	23	26	0.8
9	Oct-00	BAC HAL	30	1.9	0.8	0.6	11	15	2.4
9	Jun-01	BAC HAL	11	0.5	0.6	0.4	27	21	0.8
9	Oct-01	BAC HAL	19	1.2	0.8	0.6	12	11	1.8
9	Oct-97	BID LAE	25	1.9	0.8	0.6	9	11	2.6
9	Oct-99	BID LAE	2	0.2	0.1	0.1	30	20	0.2
9	May-00	BID LAE	29	1.3	1.7	1.0	17	12	2.3
9	Oct-00	BID LAE	5	0.3	0.2	0.1	27	26	0.5
9	Jun-01	BID LAE	4	0.2	0.2	0.1	36	33	0.3
9	Oct-01	BID LAE	5	0.3	0.2	0.2	33	31	0.5
9	Jun-01	BID MIT	1	0.0	0.0	0.0	50	50	0.1
9	Oct-01	BID MIT	2	0.1	0.1	0.1	34	33	0.2
9	May-00	BOE CYL	3	0.1	0.1	0.1	35	34	0.2
9	Oct-00	BOE CYL	9	0.6	0.2	0.1	23	26	0.7
9	Jun-01	BOE CYL	2	0.1	0.1	0.1	45	42	0.1

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
9	Oct-99	BOL AST	4	0.3	0.1	0.1	21	20	0.4
9	Oct-00	BOL AST	8	0.5	0.2	0.1	25	26	0.6
9	Jun-01	BOL AST	68	3.1	2.2	1.3	9	12	4.3
9	Oct-01	BOL AST	11	0.7	0.3	0.2	23	20	0.9
9	May-00	CAL SEP	12	0.5	0.5	0.3	25	25	0.8
9	Jun-01	CAL SEP	14	0.6	0.3	0.2	26	32	0.8
9	Oct-01	CAL SEP	2	0.1	0.1	0.1	34	33	0.2
9	May-00	CAR LUP	6	0.3	0.1	0.1	31	34	0.3
9	Jun-01	CAR LUP	2	0.1	0.1	0.1	45	42	0.1
9	Oct-99	CEL LAE	10	0.8	0.8	0.6	15	13	1.4
9	Oct-97	CEP OCC	9	0.7	0.3	0.2	16	17	0.9
9	Oct-99	CEP OCC	12	1.0	0.2	0.2	14	16	1.1
9	May-00	CEP OCC	10	0.5	0.6	0.3	28	22	0.8
9	Oct-00	CEP OCC	8	0.5	0.2	0.1	25	26	0.6
9	Jun-01	CEP OCC	10	0.4	0.6	0.4	28	21	0.8
9	Oct-01	CEP OCC	10	0.6	0.2	0.2	26	28	0.8
9	Oct-97	CIC MAC	37	2.9	1.0	0.8	6	10	3.7
9	Oct-99	CIC MAC	25	2.0	0.9	0.7	10	12	2.7
9	May-00	CIC MAC	107	4.9	5.5	3.2	8	7	8.1
9	Oct-00	CIC MAC	3	0.2	0.2	0.1	32	25	0.3
9	Jun-01	CIC MAC	72	3.2	2.1	1.2	8	13	4.5
9	Oct-01	CIC MAC	13	0.8	0.5	0.4	18	13	1.2
9	Oct-97	COR FOE	9	0.7	0.5	0.4	16	15	1.1
9	Oct-99	COR FOE	6	0.5	0.1	0.1	19	20	0.6
9	May-00	COR FOE	5	0.2	0.4	0.2	33	26	0.5
9	Oct-00	COR FOE	11	0.7	0.3	0.2	21	22	0.9
9	Jun-01	COR FOE	3	0.1	0.4	0.2	39	29	0.4
9	Oct-01	COR FOE	15	0.9	0.3	0.2	16	20	1.1
9	Oct-97	CYP HAS	7	0.5	0.2	0.2	20	20	0.7
9	Oct-00	CYP HAS	3	0.2	0.0	0.0	32	36	0.2
9	Jun-01	CYP HAS	2	0.1	0.1	0.1	45	42	0.1
9	Oct-01	CYP HAS	7	0.4	0.3	0.2	30	20	0.7
9	Oct-00	CYP VIR	3	0.2	0.1	0.1	32	31	0.3
9	Oct-01	CYP VIR	2	0.1	0.1	0.1	34	33	0.2
9	Oct-99	ELE CEL	30	2.4	2.2	1.7	7	9	4.1
9	Oct-97	ELE FAL	19	1.5	1.3	1.0	10	8	2.5
9	Oct-99	ELE FAL	3	0.2	0.0	0.0	23	32	0.2
9	May-00	ELE FAL	62	2.8	2.8	1.6	10	10	4.5
9	Oct-00	ELE FAL	33	2.1	1.5	1.0	10	9	3.1
9	Jun-01	ELE FAL	79	3.5	5.2	3.0	7	6	6.6
9	Oct-01	ELE FAL	31	1.9	1.4	1.1	8	9	3.0
9	Oct-00	ELE QUA	4	0.3	0.1	0.1	31	32	0.3
9	Jun-01	ELE QUA	19	0.9	0.5	0.3	19	25	1.2
9	Oct-01	ELE QUA	25	1.5	0.5	0.4	10	13	1.9
9	Oct-97	GAL OBT	9	0.7	0.2	0.2	16	20	0.9
9	May-00	GAL OBT	17	0.8	0.3	0.2	19	31	0.9
9	Jun-01	GAL OBT	10	0.4	0.2	0.1	28	33	0.6

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
9	Oct-01	GAL OBT	2	0.1	0.1	0.1	34	33	0.2
9	Oct-99	HYD UMB	9	0.7	0.1	0.1	16	19	0.8
9	May-00	HYD UMB	109	5.0	2.5	1.5	7	11	6.4
9	Oct-00	HYD UMB	21	1.3	0.1	0.1	14	35	1.4
9	Jun-01	HYD UMB	155	7.0	2.9	1.7	5	8	8.7
9	Oct-01	HYD UMB	12	0.7	0.2	0.2	20	27	0.9
9	Oct-97	ILE VER	8	0.6	0.5	0.4	19	15	1.0
9	May-00	ILE VER	3	0.1	0.1	0.1	35	34	0.2
9	Oct-00	ILE VER	5	0.3	0.4	0.3	27	18	0.6
9	Jun-01	ILE VER	8	0.4	0.5	0.3	31	26	0.7
9	Oct-01	ILE VER	10	0.6	0.1	0.1	26	33	0.7
9	May-00	IRI VIR	122	5.5	4.1	2.4	5	8	7.9
9	Jun-01	IRI VIR	18	0.8	0.5	0.3	21	24	1.1
9	Oct-01	IRI VIR	6	0.4	0.2	0.2	31	28	0.5
9	Jun-01	JUN ELL	3	0.1	0.1	0.1	39	42	0.2
9	Oct-99	KOS VIR	2	0.2	0.1	0.1	30	20	0.2
9	Oct-00	KOS VIR	3	0.2	0.1	0.1	32	32	0.3
9	Jun-01	LEE SP.	3	0.1	0.1	0.1	39	42	0.2
9	Oct-01	LEE SP.	14	0.9	0.5	0.4	17	13	1.2
9	Jun-01	LOB GLA	1	0.0	0.0	0.0	50	50	0.1
9	Oct-97	LON JAP	2	0.2	0.1	0.1	33	29	0.2
9	Oct-99	LON JAP	3	0.2	0.1	0.1	23	20	0.3
9	May-00	LON JAP	6	0.3	0.2	0.1	31	32	0.4
9	Oct-97	LUD MIC	6	0.5	0.2	0.2	22	20	0.6
9	May-00	LUD PAL	47	2.1	3.1	1.8	12	9	3.9
9	Oct-00	LUD PAL	49	3.1	0.9	0.6	8	14	3.7
9	Jun-01	LUD PAL	50	2.2	2.8	1.6	14	9	3.9
9	Oct-99	LUD PIL	25	2.0	0.5	0.4	10	14	2.4
9	Oct-00	LUD PIL	17	1.1	0.5	0.4	16	16	1.4
9	Jun-01	LUD PIL	5	0.2	0.1	0.1	35	40	0.3
9	Oct-01	LUD PIL	8	0.5	0.3	0.2	29	20	0.7
9	Jun-01	LYC RUB	3	0.1	0.1	0.1	39	40	0.2
9	Oct-97	MIK SCA	5	0.4	0.2	0.2	25	19	0.6
9	Oct-99	MIK SCA	53	4.2	3.1	2.4	6	5	6.6
9	May-00	MIK SCA	55	2.5	1.0	0.6	11	18	3.1
9	Oct-00	MIK SCA	51	3.2	1.3	0.9	7	11	4.1
9	Jun-01	MIK SCA	29	1.3	0.9	0.5	15	19	1.8
9	Oct-01	MIK SCA	16	1.0	0.4	0.3	13	18	1.3
9	Oct-97	MUR KEI	3	0.2	0.1	0.1	29	29	0.3
9	May-00	MUR KEI	19	0.9	1.5	0.9	18	16	1.7
9	Oct-00	MUR KEI	27	1.7	1.1	0.8	12	13	2.5
9	Jun-01	MUR KEI	55	2.5	4.0	2.3	12	7	4.8
9	Oct-01	MUR KEI	66	4.0	6.9	5.2	5	5	9.3
9	Oct-97	MYR CER	17	1.3	1.3	1.0	11	8	2.3
9	Oct-99	MYR CER	15	1.2	2.7	2.1	12	7	3.3
9	May-00	MYR CER	10	0.5	1.6	0.9	28	14	1.4
9	Oct-00	MYR CER	14	0.9	1.6	1.1	19	8	2.0

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
9	Jun-01	MYR CER	15	0.7	1.0	0.6	24	17	1.3
9	Oct-01	MYR CER	13	0.8	0.9	0.7	18	10	1.5
9	Oct-99	NYS AQU	3	0.2	0.1	0.1	23	20	0.3
9	Jun-01	NYS BIF	8	0.4	0.2	0.1	31	33	0.5
9	Oct-01	NYS BIF	1	0.1	0.0	0.0	39	39	0.1
9	Oct-97	ONO SEN	134	10.4	4.4	3.5	4	5	13.9
9	Oct-99	ONO SEN	85	6.7	3.1	2.4	4	6	9.1
9	May-00	ONO SEN	114	5.2	6.2	3.6	6	6	8.8
9	Oct-00	ONO SEN	49	3.1	1.5	1.0	8	10	4.1
9	Jun-01	ONO SEN	57	2.6	1.6	0.9	11	14	3.5
9	Oct-01	ONO SEN	57	3.5	2.0	1.5	7	8	5.0
9	Oct-97	OSM REG	56	4.3	7.1	5.6	5	3	9.9
9	Oct-99	OSM REG	58	4.6	5.7	4.4	5	3	9.0
9	May-00	OSM REG	72	3.3	9.6	5.6	9	4	8.8
9	Oct-00	OSM REG	67	4.2	9.0	6.2	4	4	10.4
9	Jun-01	OSM REG	63	2.8	8.3	4.8	10	5	7.7
9	Oct-01	OSM REG	64	3.9	7.1	5.4	6	4	9.3
9	Oct-97	PER PAL	15	1.2	0.6	0.5	13	14	1.6
9	Oct-99	PER PAL	13	1.0	1.2	0.9	13	10	2.0
9	May-00	PER PAL	10	0.5	1.2	0.7	28	17	1.2
9	Oct-00	PER PAL	16	1.0	1.3	0.9	17	11	1.9
9	Jun-01	PER PAL	10	0.4	0.5	0.3	28	26	0.7
9	Oct-01	PER PAL	16	1.0	0.3	0.2	13	20	1.2
9	Oct-00	PLU ODO	3	0.2	0.1	0.1	32	32	0.3
9	Jun-01	PLU ODO	3	0.1	0.2	0.1	39	33	0.3
9	Oct-01	PLU ODO	12	0.7	0.4	0.3	20	18	1.0
9	Oct-97	POL ARI	37	2.9	1.8	1.4	6	6	4.3
9	Oct-99	POL ARI	4	0.3	0.1	0.1	21	20	0.4
9	May-00	POL ARI	14	0.6	0.3	0.2	21	30	0.8
9	Oct-00	POL ARI	67	4.2	2.1	1.5	4	6	5.7
9	Jun-01	POL ARI	89	4.0	2.2	1.3	6	11	5.3
9	Oct-01	POL ARI	125	7.6	2.5	1.9	4	7	9.5
9	Oct-97	POL PUN	148	11.5	4.6	3.6	2	4	15.1
9	Oct-99	POL PUN	191	15.1	3.5	2.7	2	4	17.9
9	May-00	POL PUN	246	11.2	19.3	11.2	2	2	22.4
9	Oct-00	POL PUN	276	17.4	12.5	8.6	2	2	26.0
9	Jun-01	POL PUN	302	13.6	23.1	13.5	2	2	27.1
9	Oct-01	POL PUN	288	17.6	15.5	11.8	2	2	29.3
9	Oct-00	POL SAG	15	0.9	0.3	0.2	18	21	1.2
9	Oct-97	PON COR	10	0.8	0.3	0.2	15	17	1.0
9	Oct-99	PON COR	2	0.2	0.1	0.1	30	20	0.2
9	May-00	PON COR	2	0.1	0.1	0.1	39	34	0.1
9	Jun-01	PON COR	2	0.1	0.1	0.1	45	42	0.1
9	May-00	PTI CAP	40	1.8	0.6	0.4	13	21	2.2
9	Jun-01	PTI CAP	15	0.7	0.4	0.2	24	28	0.9
9	Oct-97	RHY COR	3	0.2	0.1	0.1	29	29	0.3
9	Oct-01	RHY COR	6	0.4	0.2	0.2	31	31	0.5

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
9	Oct-97	ROS PAL	6	0.5	0.2	0.2	22	20	0.6
9	Oct-99	ROS PAL	3	0.2	0.1	0.1	23	20	0.3
9	May-00	ROS PAL	3	0.1	0.1	0.1	35	34	0.2
9	Oct-00	ROS PAL	5	0.3	0.4	0.3	27	18	0.6
9	Jun-01	ROS PAL	4	0.2	0.1	0.1	36	39	0.2
9	Oct-01	ROS PAL	10	0.6	0.2	0.2	26	28	0.8
9	Oct-97	RUB ARG	17	1.3	1.7	1.3	11	7	2.7
9	Oct-99	RUB ARG	29	2.3	2.6	2.0	8	8	4.3
9	May-00	RUB ARG	15	0.7	1.6	0.9	20	14	1.6
9	Oct-00	RUB ARG	18	1.1	1.8	1.2	15	7	2.4
9	Jun-01	RUB ARG	21	0.9	2.4	1.4	17	10	2.3
9	Oct-01	RUB ARG	30	1.8	2.7	2.0	9	6	3.9
9	May-00	RUM VER	32	1.5	1.0	0.6	16	18	2.0
9	Jun-01	RUM VER	21	0.9	0.4	0.2	17	29	1.2
9	May-00	SAG LAN	5	0.2	0.2	0.1	33	32	0.3
9	Oct-00	SAG LAN	1	0.1	0.0	0.0	37	37	0.1
9	Jun-01	SAG LAN	3	0.1	0.1	0.1	39	42	0.2
9	Oct-97	SAL CAR	5	0.4	0.2	0.2	25	20	0.5
9	Oct-99	SAL CAR	3	0.2	0.1	0.1	23	20	0.3
9	May-00	SAL CAR	12	0.5	0.4	0.2	25	26	0.8
9	Oct-00	SAL CAR	5	0.3	0.2	0.1	27	26	0.5
9	Jun-01	SAL CAR	8	0.4	0.4	0.2	31	29	0.6
9	Oct-01	SAL CAR	12	0.7	0.5	0.4	20	13	1.1
9	May-00	SAM CAN	2	0.1	0.1	0.1	39	34	0.1
9	Oct-97	SAU CER	28	2.2	0.7	0.5	8	12	2.7
9	May-00	SAU CER	191	8.7	12.1	7.0	4	3	15.7
9	Oct-00	SAU CER	1	0.1	0.0	0.0	37	37	0.1
9	Jun-01	SAU CER	184	8.3	16.6	9.7	3	3	17.9
9	Oct-97	SCI CYP	2	0.2	0.1	0.1	33	29	0.2
9	Oct-99	SCI CYP	3	0.2	0.1	0.1	23	20	0.3
9	Oct-97	SCI TAB	5	0.4	0.1	0.1	25	28	0.5
9	Oct-99	SCI TAB	9	0.7	0.2	0.2	16	17	0.9
9	May-00	SCI TAB	39	1.8	0.8	0.5	14	20	2.2
9	Oct-00	SCI TAB	25	1.6	0.3	0.2	13	20	1.8
9	Jun-01	SCI TAB	52	2.3	1.3	0.8	13	15	3.1
9	Oct-01	SCI TAB	21	1.3	0.5	0.4	11	13	1.7
9	Oct-97	TOX RAD	3	0.2	0.1	0.1	29	29	0.3
9	May-00	TOX RAD	11	0.5	0.6	0.3	27	22	0.8
9	May-00	TRI WAL	3	0.1	0.1	0.1	35	34	0.2
9	Oct-00	TRI WAL	1	0.1	0.0	0.0	37	37	0.1
9	Jun-01	TRI WAL	1	0.0	0.0	0.0	50	50	0.1
9	Oct-99	VIG LUT	9	0.7	0.2	0.2	16	17	0.9
9	May-00	VIG LUT	38	1.7	1.7	1.0	15	12	2.7
9	Oct-00	VIG LUT	13	0.8	0.5	0.3	20	17	1.2
9	Oct-97	WIS FRU	7	0.5	0.2	0.2	20	20	0.7
9	Oct-00	WIS FRU	11	0.7	0.3	0.2	21	22	0.9
9	Jun-01	WIS FRU	17	0.8	0.7	0.4	22	20	1.2

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
9	Oct-01	WIS FRU	11	0.7	0.3	0.2	23	20	0.9
9	Oct-97	ZIZ AQU	6	0.5	0.2	0.2	22	20	0.6
9	Oct-97	ZIZ MIL	490	38.0	88.5	69.3	1	1	107.3
9	Oct-99	ZIZ MIL	496	39.3	90.9	70.5	1	1	109.8
9	May-00	ZIZ MIL	495	22.5	79.3	46.0	1	1	68.5
9	Oct-00	ZIZ MIL	493	31.1	90.2	62.1	1	1	93.2
9	Jun-01	ZIZ MIL	488	21.9	70.9	41.4	1	1	63.3
9	Oct-01	ZIZ MIL	493	30.1	75.7	57.4	1	1	87.5
10	Oct-97	ALT PHI	50	3.9	7.6	7.3	5	3	11.1
10	Oct-99	ALT PHI	53	3.7	6.1	4.5	6	6	8.1
10	May-00	ALT PHI	53	2.9	9.3	6.1	12	4	9.0
10	Oct-00	ALT PHI	53	3.1	8.3	5.0	9	5	8.1
10	Jun-01	ALT PHI	57	3.1	9.6	6.4	10	4	9.5
10	Oct-01	ALT PHI	56	3.5	8.0	6.2	9	3	9.7
10	Oct-97	AMA CAN	8	0.6	0.2	0.2	13	13	0.8
10	Oct-99	AMA CAN	5	0.3	0.2	0.1	12	11	0.5
10	May-00	AMA CAN	8	0.4	0.2	0.1	16	16	0.6
10	Oct-00	AMA CAN	65	3.8	3.9	2.4	7	7	6.2
10	Jun-01	AMA CAN	131	7.1	8.0	5.4	5	5	12.4
10	Oct-01	AMA CAN	65	4.1	1.9	1.5	7	8	5.6
10	Oct-99	AST ELL	3	0.2	0.1	0.1	15	15	0.3
10	May-00	AST ELL	4	0.2	0.2	0.1	17	17	0.3
10	Oct-97	AST TEN	32	2.5	0.9	0.9	7	9	3.4
10	Oct-99	AST TEN	249	17.2	18.8	13.8	3	3	30.9
10	May-00	AST TEN	191	10.3	11.1	7.3	3	3	17.6
10	Oct-00	AST TEN	309	18.0	29.1	17.7	2	2	35.7
10	Jun-01	AST TEN	311	16.8	23.9	16.0	2	2	32.8
10	Oct-01	AST TEN	340	21.5	23.7	18.4	2	2	39.8
10	Oct-97	BID LAE	21	1.6	0.4	0.4	11	12	2.0
10	Oct-99	BID LAE	2	0.1	0.1	0.1	16	15	0.2
10	May-00	BID LAE	15	0.8	0.4	0.3	14	15	1.1
10	Oct-97	CIC MAC	2	0.2	0.1	0.1	17	17	0.3
10	Oct-97	ELE FAL	67	5.2	4.4	4.2	4	4	9.4
10	Oct-99	ELE FAL	63	4.3	6.2	4.5	5	5	8.9
10	May-00	ELE FAL	78	4.2	8.0	5.3	8	6	9.5
10	Oct-00	ELE FAL	38	2.2	2.2	1.3	10	9	3.6
10	Jun-01	ELE FAL	46	2.5	4.1	2.7	13	8	5.2
10	Oct-01	ELE FAL	32	2.0	1.9	1.5	10	9	3.5
10	Oct-97	IRI VIR	5	0.4	0.2	0.2	14	13	0.6
10	Oct-99	IRI VIR	6	0.4	0.1	0.1	11	14	0.5
10	May-00	IRI VIR	39	2.1	1.2	0.8	13	13	2.9
10	May-00	LIL CHI	95	5.1	3.8	2.5	7	9	7.6
10	Oct-00	LIL CHI	68	4.0	1.3	0.8	6	10	4.8
10	Jun-01	LIL CHI	62	3.3	1.3	0.9	9	12	4.2
10	Oct-01	LIL CHI	92	5.8	1.5	1.2	6	10	7.0
10	Oct-97	PEL VIR	9	0.7	0.5	0.5	12	11	1.2
10	Oct-99	PEL VIR	5	0.3	0.3	0.2	12	10	0.6

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	Relative	Freq Rank	Cover Rank	IV
10	May-00	PEL VIR	181	9.8	13.6	8.9	4	2	18.7
10	Oct-00	PEL VIR	2	0.1	0.1	0.1	13	13	0.2
10	Jun-01	PEL VIR	54	2.9	1.2	0.8	11	13	3.7
10	Oct-97	PLU ODO	22	1.7	1.0	1.0	10	8	2.7
10	Oct-99	PLU ODO	36	2.5	1.4	1.0	8	8	3.5
10	May-00	PLU ODO	77	4.1	2.4	1.6	9	12	5.7
10	Oct-00	PLU ODO	104	6.1	3.6	2.2	5	8	8.2
10	Jun-01	PLU ODO	119	6.4	4.5	3.0	6	7	9.4
10	Oct-01	PLU ODO	94	5.9	2.8	2.2	5	7	8.1
10	Oct-97	POL ARI	24	1.9	0.9	0.9	8	10	2.7
10	Oct-97	POL PUN	44	3.4	1.1	1.1	6	7	4.5
10	Oct-99	POL PUN	25	1.7	0.7	0.5	9	9	2.2
10	May-00	POL PUN	11	0.6	0.9	0.6	15	14	1.2
10	Oct-97	PON COR	1	0.1	0.0	0.0	18	18	0.1
10	Jun-01	RUM VER	6	0.3	0.5	0.3	14	14	0.7
10	Oct-97	SAG LAN	5	0.4	0.1	0.1	14	16	0.5
10	Oct-99	SAG LAN	4	0.3	0.2	0.1	14	11	0.4
10	May-00	SAG LAN	97	5.2	2.5	1.7	6	11	6.9
10	Oct-00	SAG LAN	16	0.9	0.4	0.3	12	12	1.2
10	Jun-01	SAG LAN	114	6.2	3.1	2.1	7	10	8.2
10	Oct-01	SAG LAN	10	0.6	0.3	0.2	12	11	0.9
10	Oct-97	SCI ROB	5	0.4	0.2	0.2	14	13	0.6
10	Oct-99	SCI ROB	10	0.7	0.2	0.1	10	11	0.8
10	May-00	SCI ROB	62	3.3	3.7	2.4	10	10	5.8
10	Oct-00	SCI ROB	25	1.5	0.8	0.5	11	11	1.9
10	Jun-01	SCI ROB	48	2.6	2.7	1.8	12	11	4.4
10	Oct-01	SCI ROB	13	0.8	0.2	0.2	11	12	1.0
10	Oct-97	SCI TAB	463	36.0	53.0	50.6	1	1	86.6
10	Oct-99	SCI TAB	467	32.2	65.1	47.6	1	1	79.8
10	May-00	SCI TAB	481	25.9	75.4	49.7	1	1	75.6
10	Oct-00	SCI TAB	491	28.6	79.2	48.1	1	1	76.7
10	Jun-01	SCI TAB	465	25.1	69.9	46.7	1	1	71.9
10	Oct-01	SCI TAB	462	29.2	70.1	54.2	1	1	83.4
10	Oct-97	SPA ALT	24	1.9	1.5	1.4	8	6	3.3
10	Oct-99	SPA ALT	41	2.8	3.0	2.2	7	7	5.0
10	May-00	SPA ALT	56	3.0	4.0	2.6	11	8	5.7
10	Oct-00	SPA ALT	59	3.4	6.5	4.0	8	6	7.4
10	Jun-01	SPA ALT	65	3.5	5.0	3.3	8	6	6.9
10	Oct-01	SPA ALT	60	3.8	5.7	4.4	8	5	8.2
10	Oct-97	TYP ANG	168	13.1	4.3	4.1	3	5	17.2
10	Oct-99	TYP ANG	153	10.5	8.1	5.9	4	4	16.5
10	May-00	TYP ANG	160	8.6	5.8	3.8	5	7	12.5
10	Oct-00	TYP ANG	209	12.2	14.1	8.6	4	4	20.7
10	Jun-01	TYP ANG	233	12.6	12.1	8.1	3	3	20.7
10	Oct-01	TYP ANG	202	12.8	7.4	5.7	3	4	18.5
10	Oct-97	ZIZ MIL	337	26.2	28.2	26.9	2	2	53.1
10	Oct-99	ZIZ MIL	329	22.7	26.1	19.1	2	2	41.8

Table A-2. Continued

Q	Event	Species	Total Freq	Rel Freq	% Cover Range Avg	% Cover Range Relative	Freq Rank	Cover Rank	IV
10	May-00	ZIZ MIL	248	13.4	9.2	6.1	2	5	19.4
10	Oct-00	ZIZ MIL	276	16.1	15.2	9.2	3	3	25.3
10	Jun-01	ZIZ MIL	140	7.6	3.6	2.4	4	9	10.0
10	Oct-01	ZIZ MIL	158	10.0	5.6	4.3	4	6	14.3

APPENDIX B

WATER LEVEL DATA

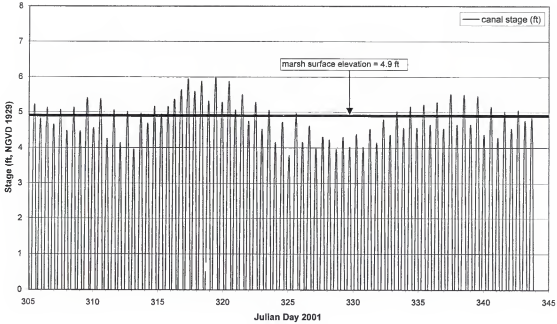

Figure B-1. Q1 tidal creek stage (November 1, 2001 - December 10, 2001).

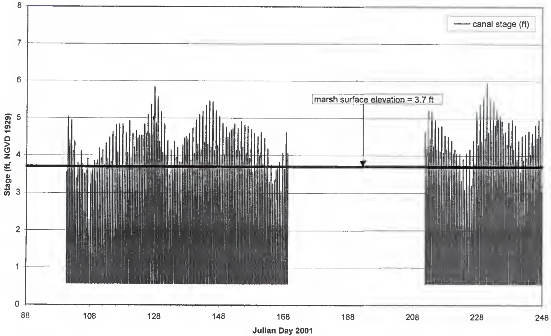

Figure B-2. Q2 tidal creek stage (April 10, 2001 - September 5, 2001).

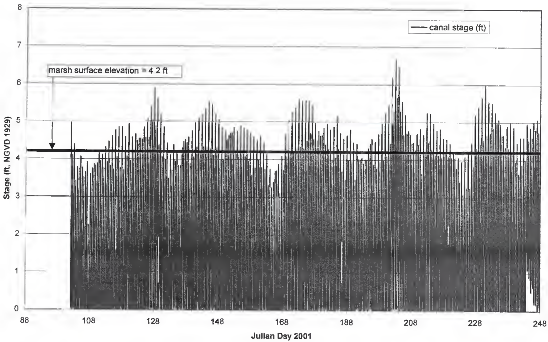

Figure B-3. Q3 tidal creek stage (April 11, 2001 - September 5, 2001).

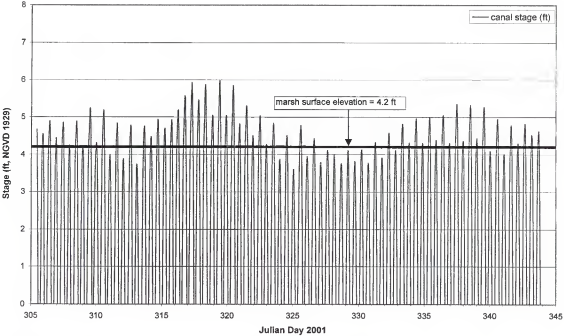

Figure B-4. Q3 tidal creek stage (November 1, 2001 - December 10, 2001).

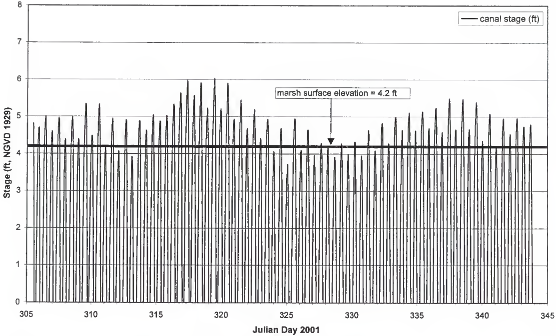

Figure B-5. Q4 tidal creek stage (November 1, 2001 - December 10, 2001).

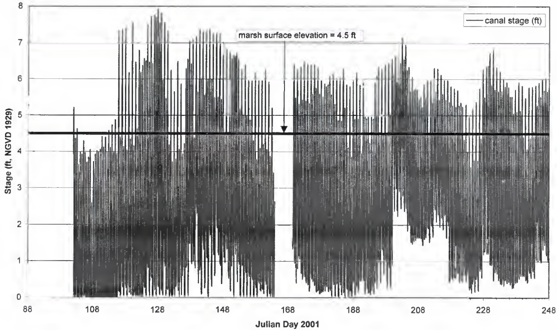

Figure B-6. Q5 tidal creek stage (April 11, 2001 - September 5, 2001).

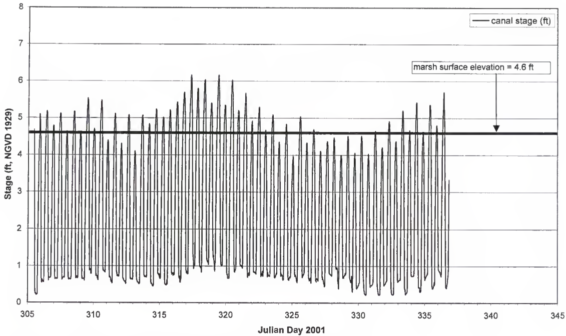

Figure B-7. Q6 tidal creek stage (November 1, 2001 - December 2, 2001).

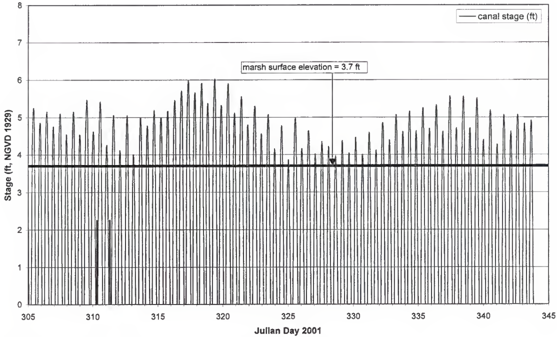

Figure B-8. Q7 tidal creek stage (November 1, 2001 - December 10, 2001).

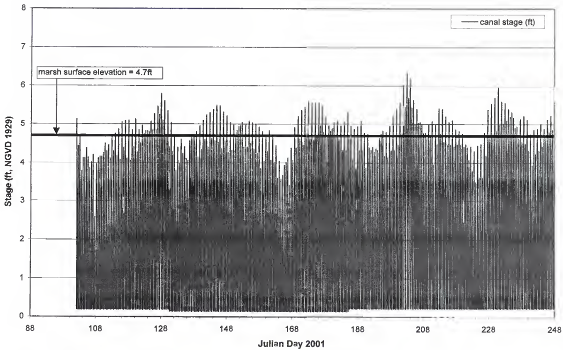

Figure B-9. Q8 tidal creek stage (April 11, 2001 - September 5, 2001).

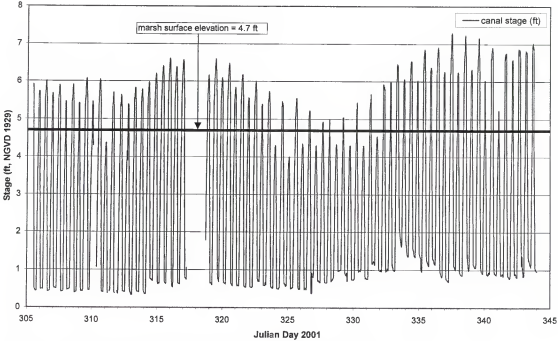

Figure B-10. Q8 tidal creek stage (November 1, 2001 - December 10, 2001).

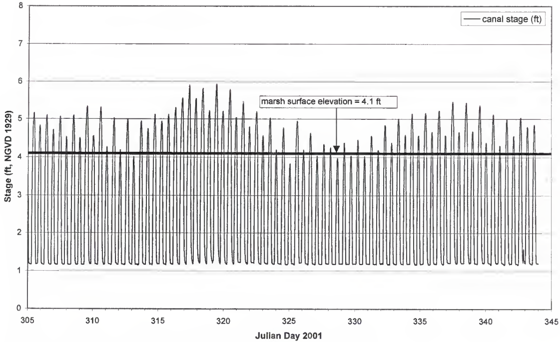

Figure B-11. Q9 tidal creek stage (November 1, 2001 - December 10, 2001).

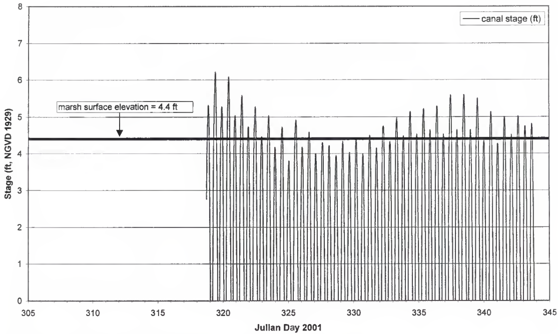

Figure B-12. Q10 tidal creek stage (November 14, 2001 - December 10, 2001).

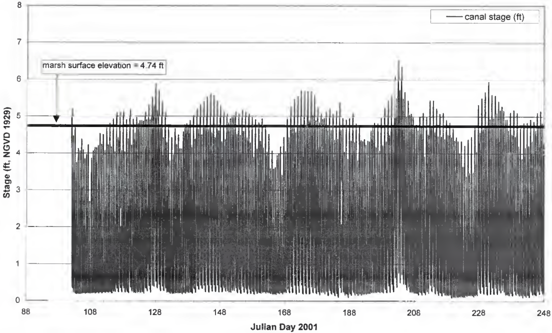

Figure B-13. Datalogging Station W tidal creek stage (April 11, 2001 - September 5, 2001).

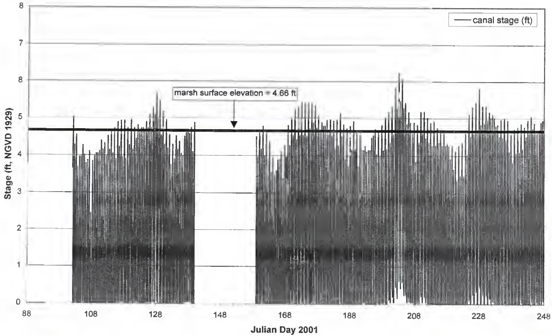

Figure B-14. Datalogging Station E tidal creek stage (April 11, 2001 - September 5, 2001).

APPENDIX C
SALINITY DATA

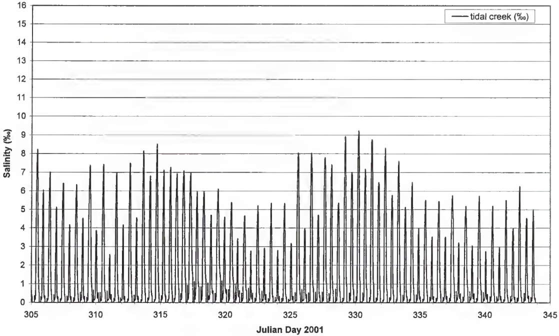

Figure C-1. Q1 salinity data records for tidal creek (November 1, 2001 - December 10, 2001).

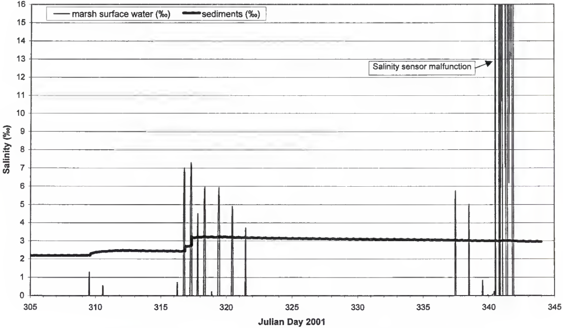

Figure C-2. Q1 salinity data records for marsh surface water and marsh sediments (November 1, 2001 - December 10, 2001).

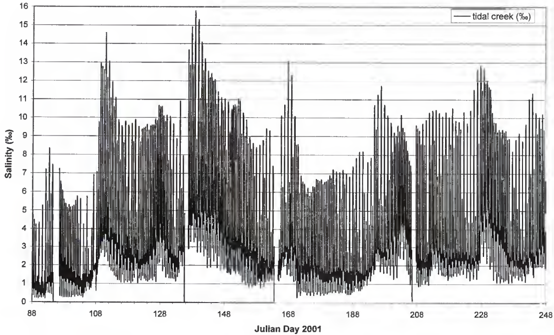

Figure C-3. Q2 salinity data records for tidal creek (March 29, 2001 - September 5, 2001).

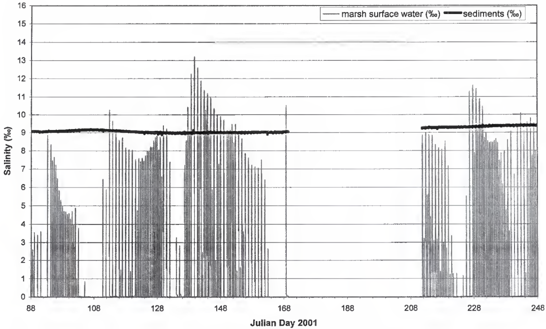

Figure C-4. Q2 salinity data records for marsh surface water and marsh sediments (March 29, 2001 - September 5, 2001).

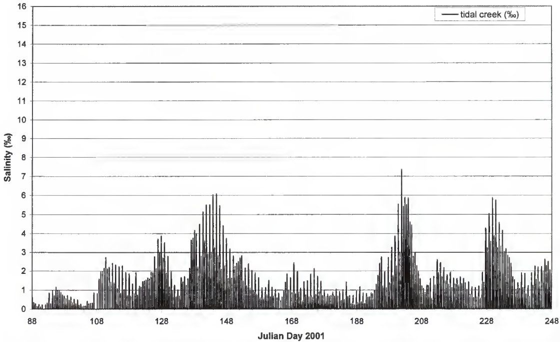

Figure C-5. Q3 salinity data records for tidal creek (March 29, 2001 - September 5, 2001).

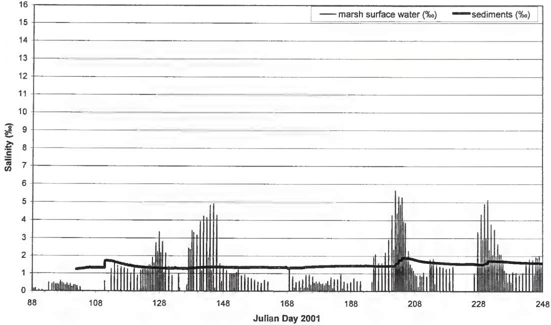

Figure C-6. Q3 salinity data records for marsh surface water and marsh sediments (March 29, 2001 - September 5, 2001).

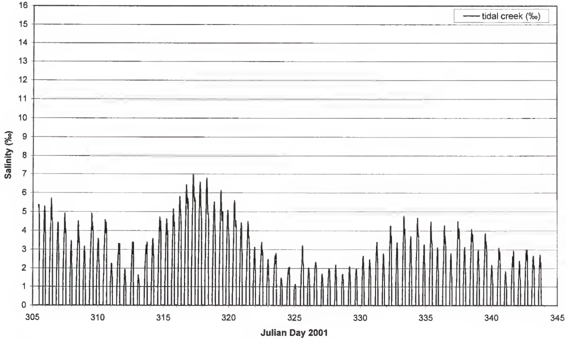

Figure C-7. Q3 salinity data records for tidal creek (November 1, 2001 - December 10, 2001).

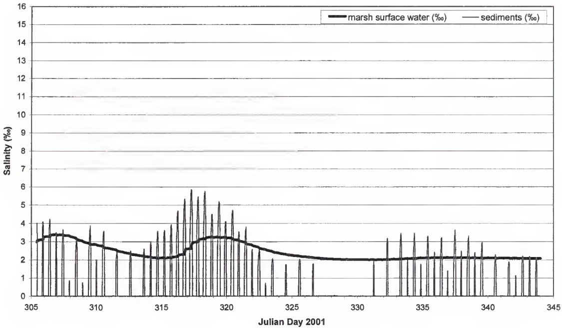

Figure C-8. Q3 salinity data records for marsh surface water and marsh sediments (November 1, 2001 - December 10, 2001).

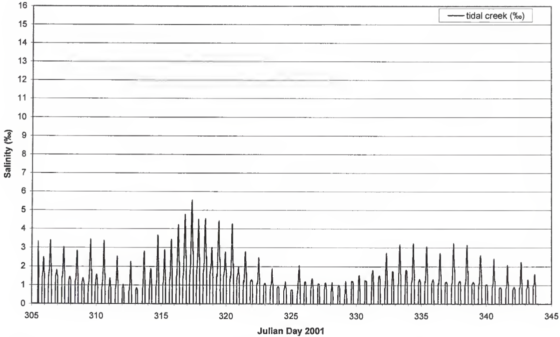

Figure C-9. Q4 salinity data records for tidal creek (November 1, 2001 - December 10, 2001).

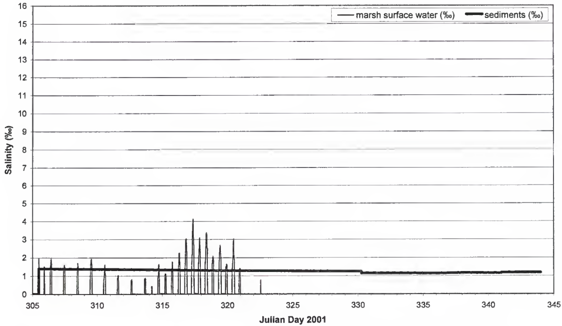

Figure C-10. Q4 salinity data records for marsh surface water and marsh sediments (November 1, 2001 - December 10, 2001).

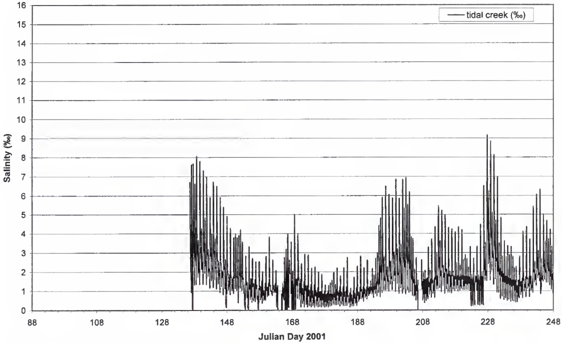

Figure C-11. Q5 salinity data records for tidal creek (May 16, 2001 - September 5, 2001).

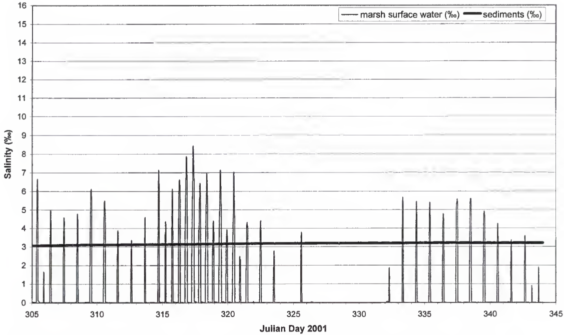

Figure C-12. Q5 salinity data records for marsh surface water and marsh sediments (November 1, 2001 - December 10, 2001).

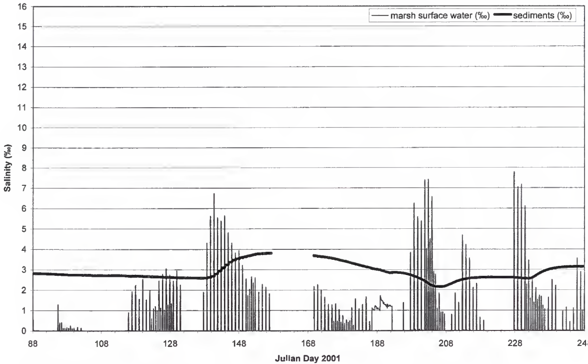

Figure C-13. Q5 salinity data records for marsh surface water and marsh sediments (March 29, 2001 - September 5, 2001).

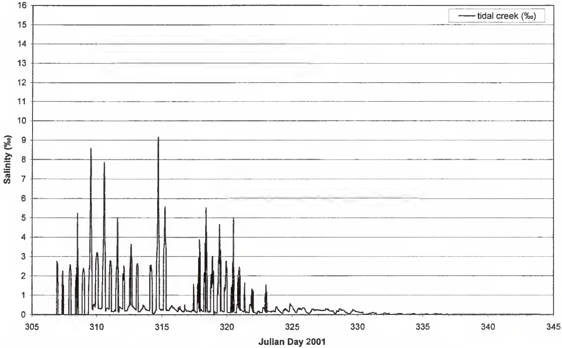

Figure C-14. Q6 salinity data records for tidal creek (November 2, 2001 - December 1, 2001).

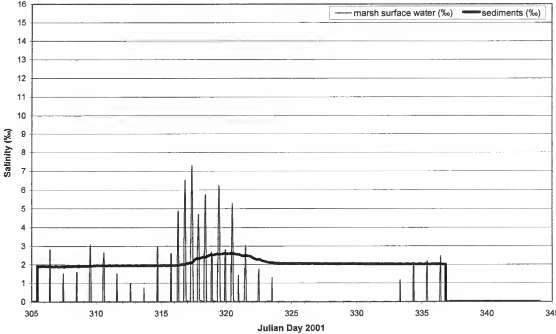

Figure C-15. Q6 salinity data records for marsh surface water and marsh sediments (November 2, 2001 - December 1, 2001).

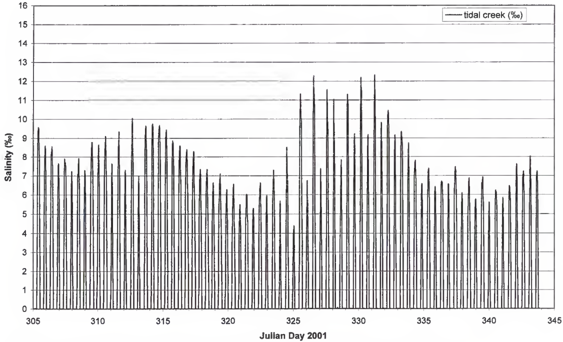

Figure C-16. Q7 salinity data records for tidal creek (November 1, 2001 - December 10, 2001).

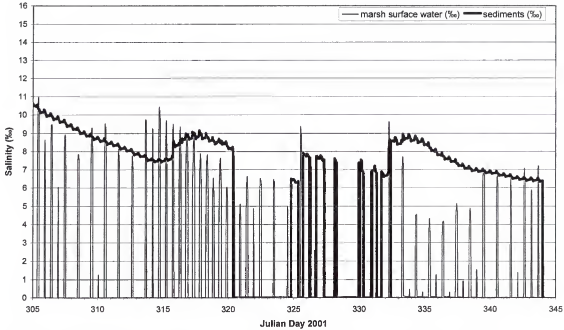

Figure C-17. Q7 salinity data records for marsh surface water and marsh sediments (November 1, 2001 - December 10, 2001).

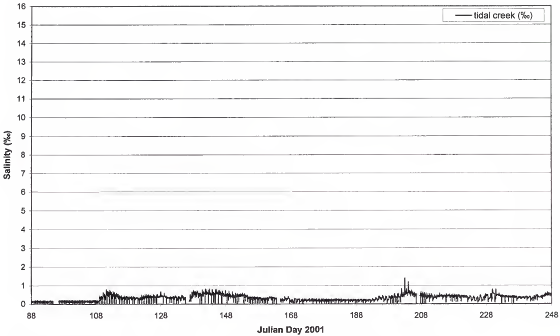

Figure C-18. Q8 salinity data records for tidal creek (March 29, 2001 - September 5, 2001).

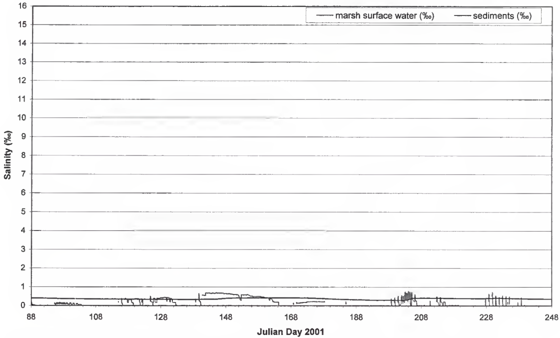

Figure C-19. Q8 salinity data records for marsh surface water and marsh sediments (March 29, 2001 - September 5, 2001).

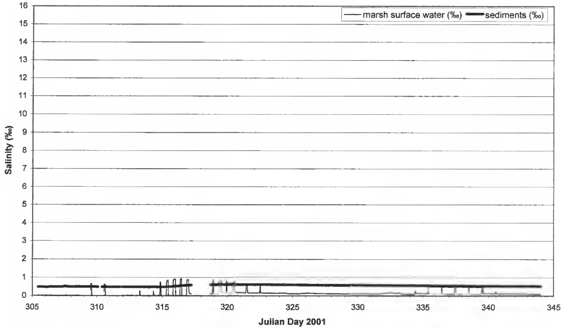

Figure C-20. Q8 salinity data records for marsh surface water and marsh sediments (November 1, 2001 - December 10, 2001).

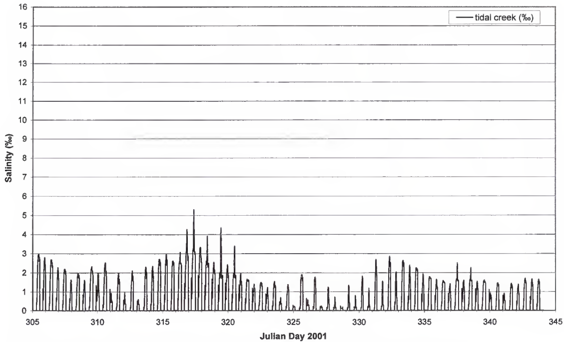

Figure C-21. Q9 salinity data records for tidal creek (November 1, 2001 - December 10, 2001).

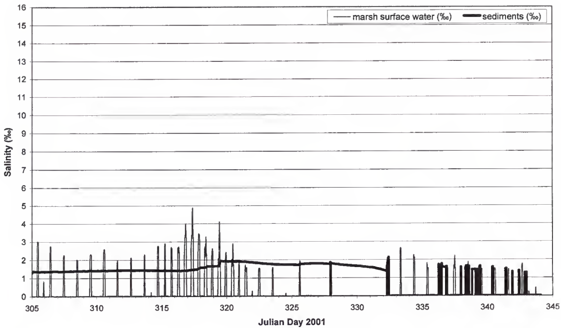

Figure C-22. Q9 salinity data records for marsh surface water and marsh sediments (November 1, 2001 - December 10, 2001).

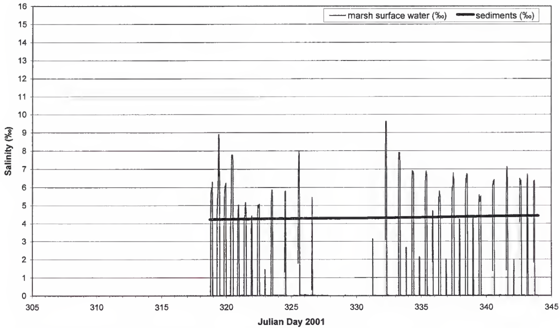

Figure C-23. Q10 salinity data records for marsh surface water and marsh sediments (November 14, 2001 - December 10, 2001).

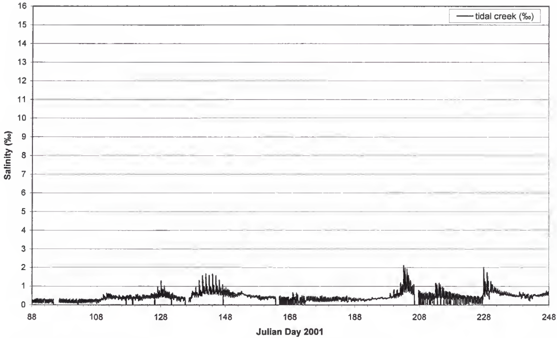

Figure C-24. Datalogging Station E salinity data records for tidal creek (March 29, 2001 - September 5, 2001).

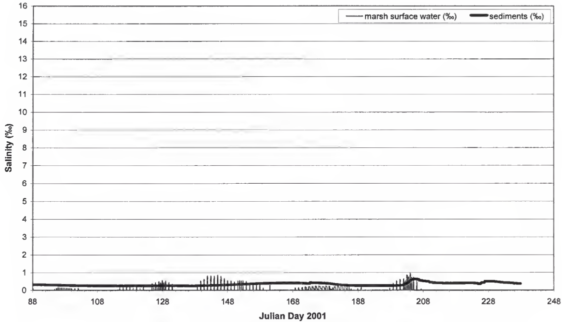

Figure C-25. Datalogging Station E salinity data records for marsh surface water and marsh sediments (March 29, 2001 - August 25, 2001).

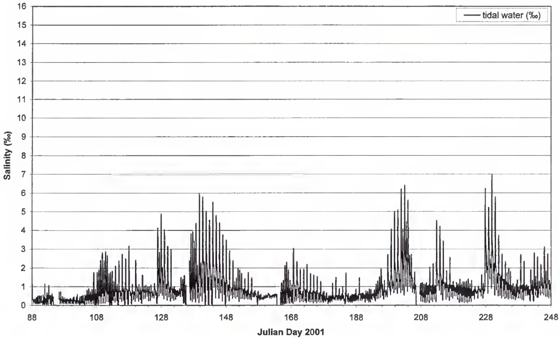

Figure C-26. Datalogging Station W salinity data records for tidal creek (March 29, 2001 - September 5, 2001).

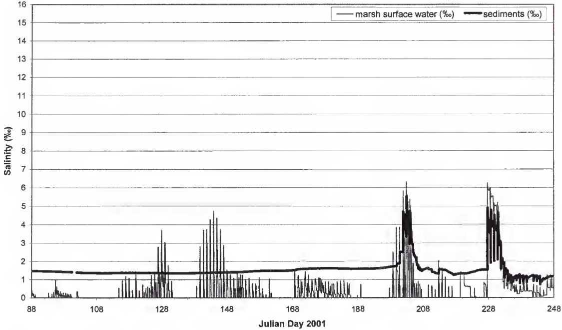

Figure C-27. Datalogging Station W salinity data records for marsh surface water and marsh sediments (March 29, 2001 - September 5, 2001).

APPENDIX D
SURVEYED CROSS-SECTIONS OF FORMER MARGIN DITCHES AND MAIN WATER SUPPLY CANALS

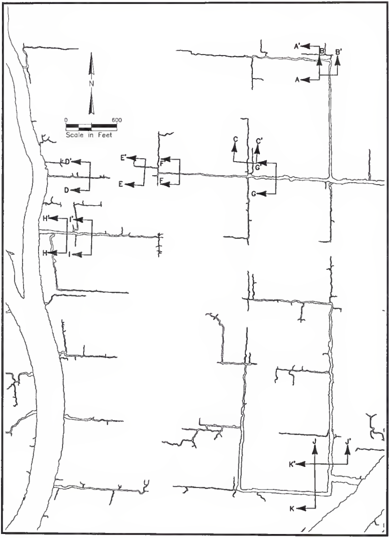

Figure D-1. Section A-A' through K-K' surveyed cross-section locations.

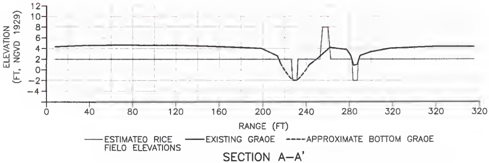

Figure D-2. Section A-A' surveyed cross-section.

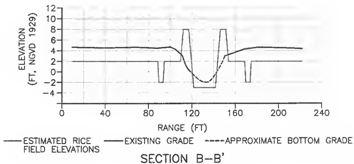

Figure D-3. Section B-B' surveyed cross-section.

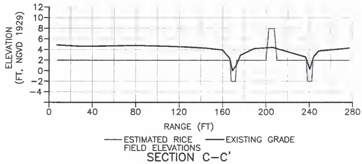

Figure D-4. Section C-C' surveyed cross-section.

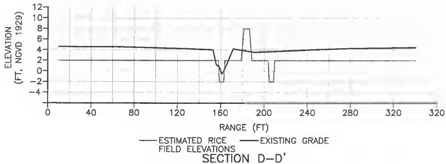

Figure D-5. Section D-D' surveyed cross-section.

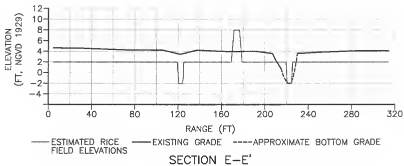

Figure D-6. Section E-E' surveyed cross-section.

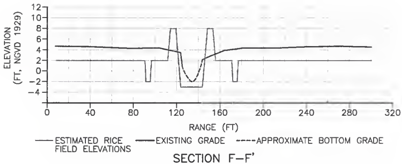

Figure D-7. Section F-F' surveyed cross-section.

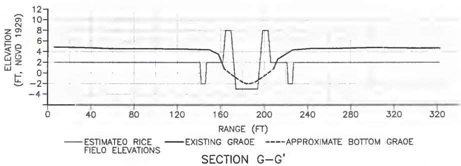

Figure D-8. Section G-G' surveyed cross-section.

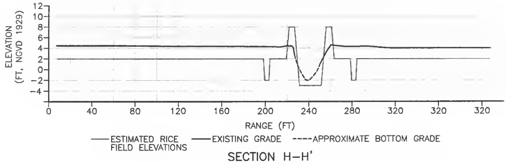

Figure D-9. Section H-H' surveyed cross-section.

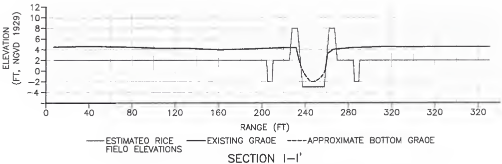

Figure D-10. Section I-I' surveyed cross-section.

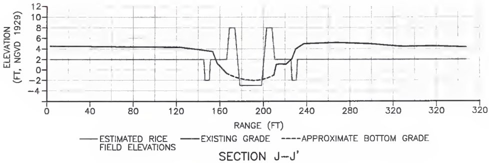

Figure D-11. Section J-J' surveyed cross-section.

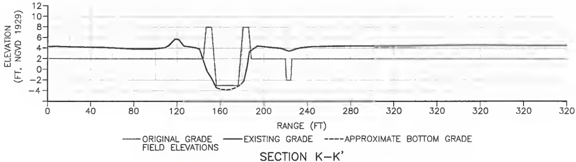

Figure D-12. Section K-K' surveyed cross-section.

BIOGRAPHICAL SKETCH

John Bossart was born October 28, 1956, in Akron, Ohio. The son of an aerospace engineer and a registered nurse, Mr. Bossart grew up in Cocoa, Florida, near the waters of the Indian River lagoon. He attended Brevard College in Brevard, North Carolina, and the University of South Florida in Tampa where he received an undergraduate degree in microbiology in 1979. He continued his education at the University of Florida and received a Master of Science in environmental biology in 1982 from the Department of Environmental Engineering Sciences. Mr. Bossart then worked for a number of years in the wetland-permitting program at the Florida Department of Environmental Regulation in Tallahassee. After returning to Gainesville in 1991, Mr. Bossart has worked as a Senior Scientist for two different consulting engineering firms, being employed with Applied Technology & Management, Inc., since 1994 while simultaneously pursuing a doctoral degree in systems ecology from the University of Florida. Mr. Bossart married his graduate school sweetheart, Jean-Louise Bai, in 1989. They currently live in Gainesville with their three dogs and five cats.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Clay L. Montague, Chairman
Associate Professor of Environmental Engineering Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Mark T. Brown
Associate Professor of Environmental Engineering Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Thomas L. Crisman
Professor of Environmental Engineering Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Scot E. Smith
Associate Professor of Civil and Coastal Engineering